

Dust Storms, Climate and a Pan-American Center for the World Meteorological Organization Sand and Dust Storm System

William A. Sprigg
Chapman University
5 March 2012

- Advances in Forecasting
- Considering Climate
- Airborne Dust, Human Health & Public Health Services
- Paths to Address an Ignored & Growing Problem:
 - The World Meteorological Organization Sand & Dust Storm System
 - A Pan-American Center, a Federated Node for Contributing Data, Knowledge & Tools to Advance Science & to Speed & Expand Applications

Predicting Airborne Desert Dust

William A. Sprigg

Chapman University & The University of Arizona

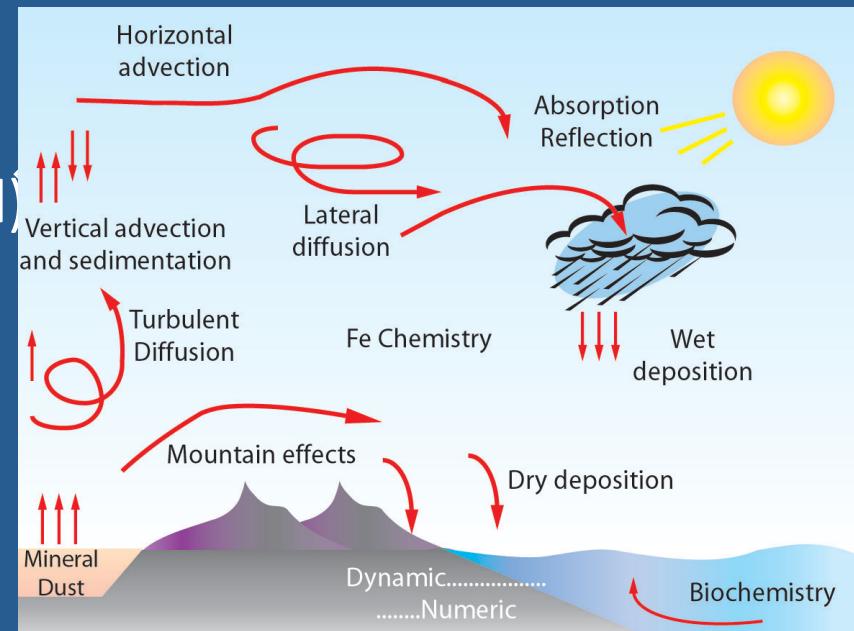
Phoenix, July 5th, 2011



Dust Regional Atmospheric Model

DREAM 4-8 particle bins

- **Model predictions (72-h):**
- Horizontal distribution
 - Surface concentration
 - Total column mass (dust load)
 - Wet, dry, total deposition
 - Meteorological variables
- Vertical distribution
 - Concentration
 - Cross sections
 - Fixed point/time profiles
- Fixed point (selected sites/cities)



MODEL SYSTEM

DREAM (in-line) driven by NCEP/Eta or NCEP/NMM

VARIABLE INPUT DATA

NCEP or ECMWF global weather (initial & boundary conditions)

(SEMI) PERMANENT INPUT DATA

soil and land cover

DUST PRODUCTION FACTORS:

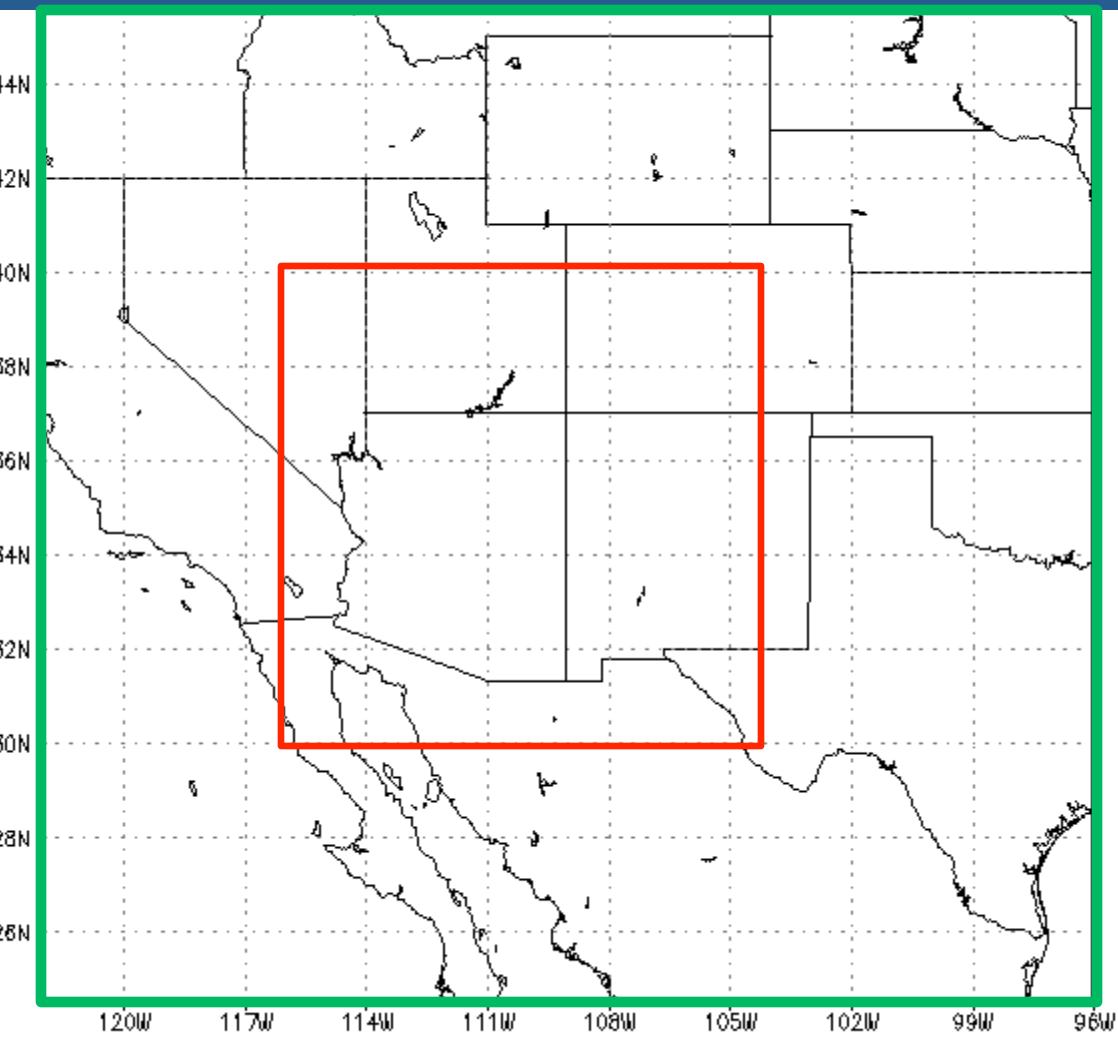
soil structure

vegetation cover

soil moisture

atmospheric turbulence

DREAM domains & resolutions



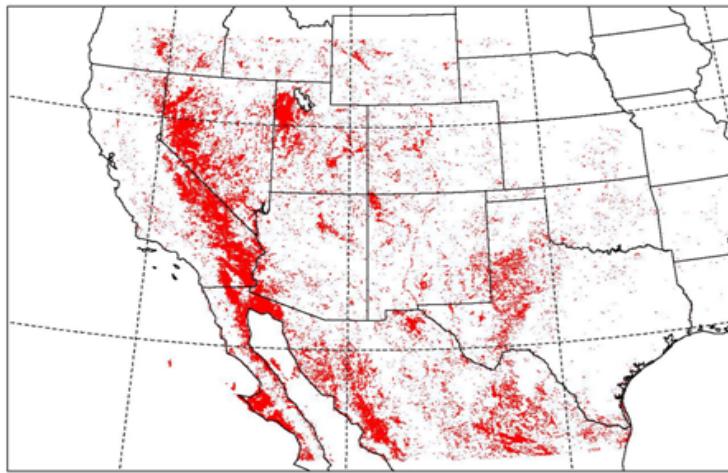
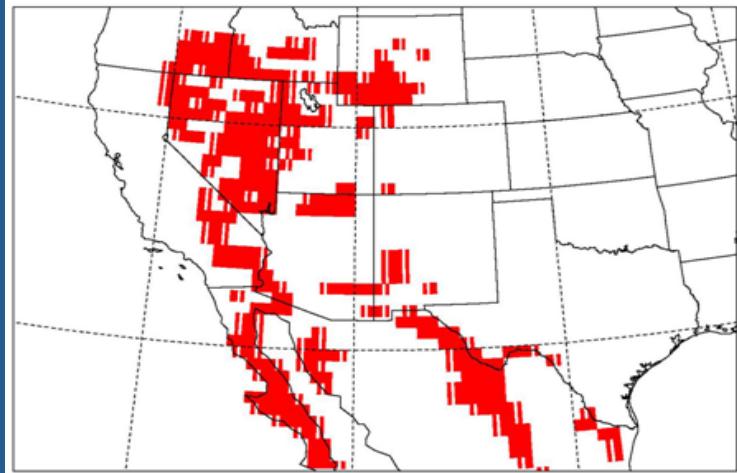
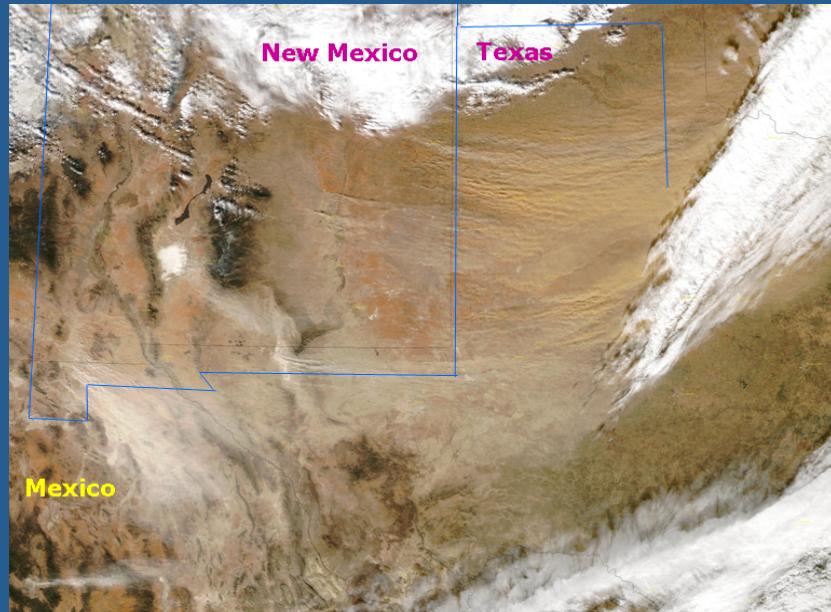
Large domain:
W95.6-W122.4 ; N24.3-N45.7
resolution: 50 km

Small domain:
W104-W116 ; N30-N40
resolution: 7.5 km and 3.7 km

Resolution is important



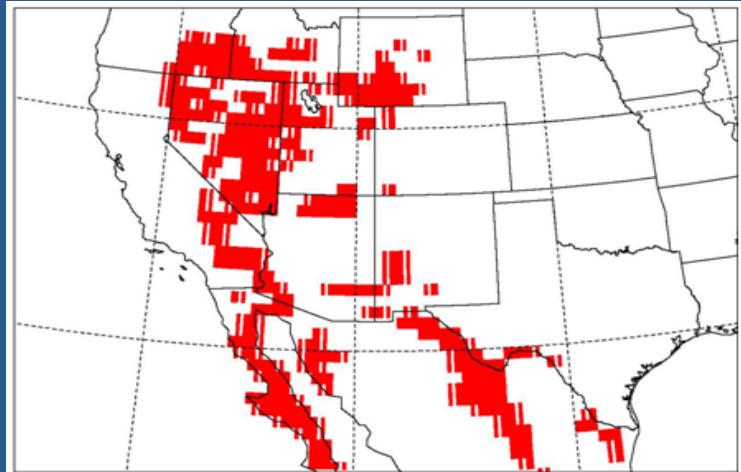
Terra MODIS image, 15 December, 2003. The bright circular spot at left-center is White Sands National Monument.



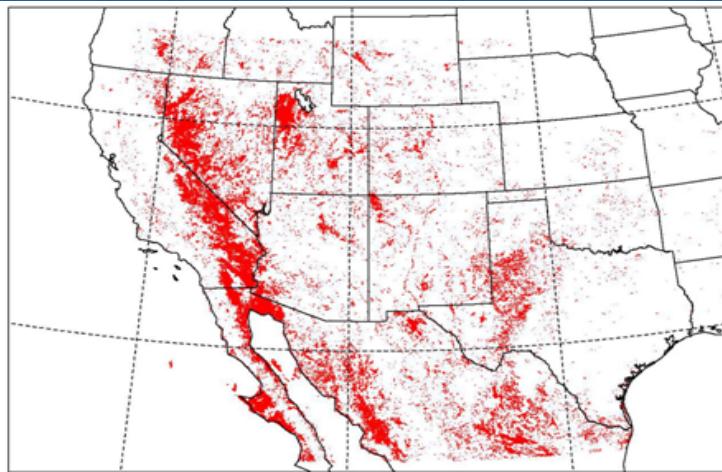
Comparison of the Olson World Ecosystem (OWE) barren category (left) with MOD12Q1 barren categories in the DREAM/SW domain (right).

Hindcasting Dust Storms

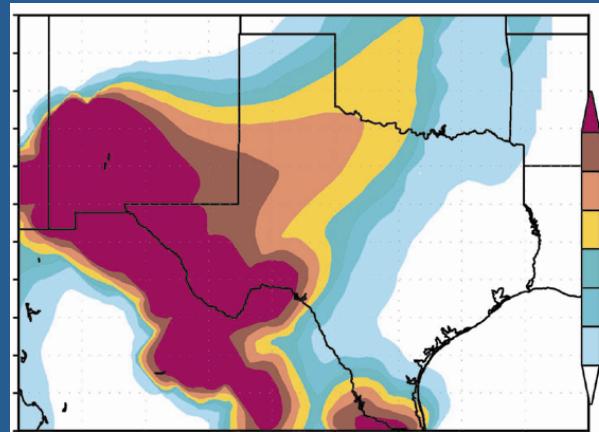
15 – 16 December 2003 Dust Storm



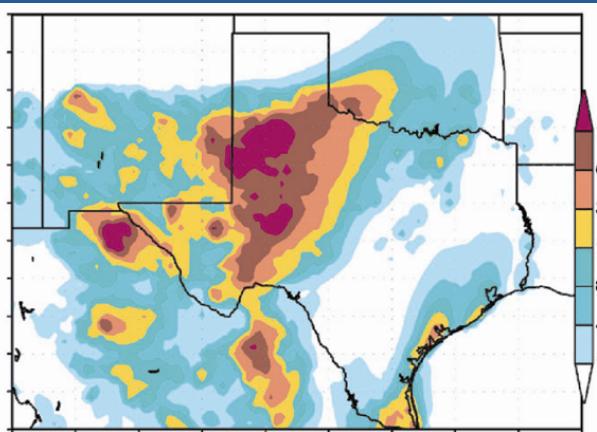
- Olson Land Cover



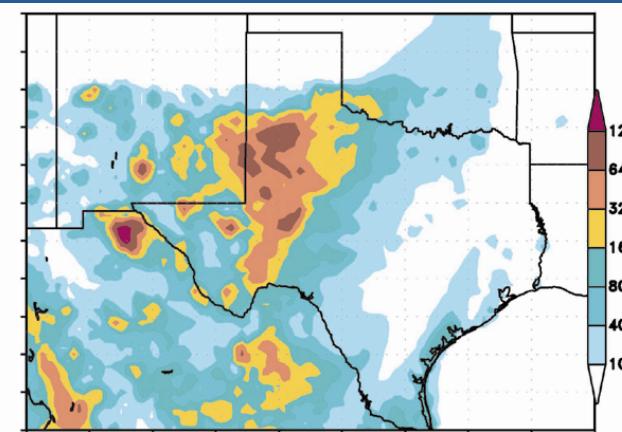
- MODIS Land Cover



Hindcast OLSON & ETA

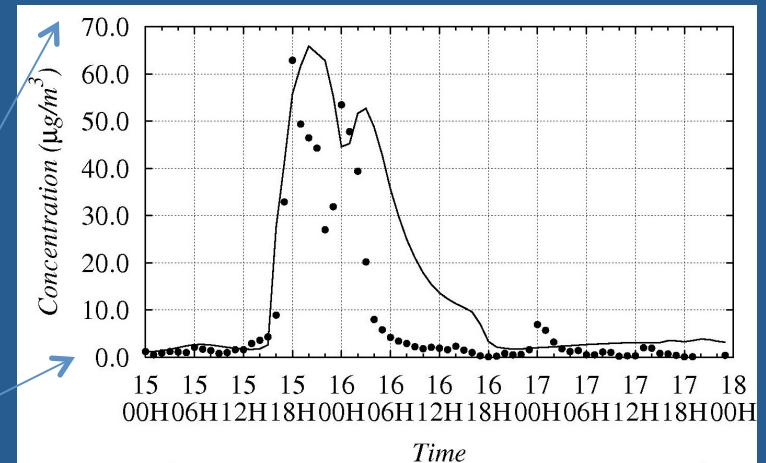
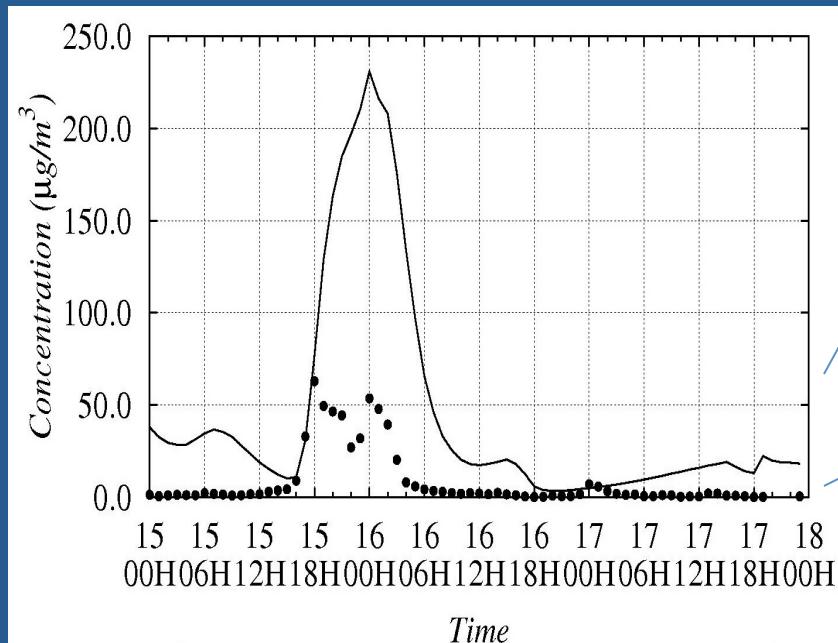


Hindcast MODIS & ETA



Hindcast MODIS & NMM

Modeled and Measured PM_{2.5} Concentrations at Odessa, Texas, Dec. 15, 2003



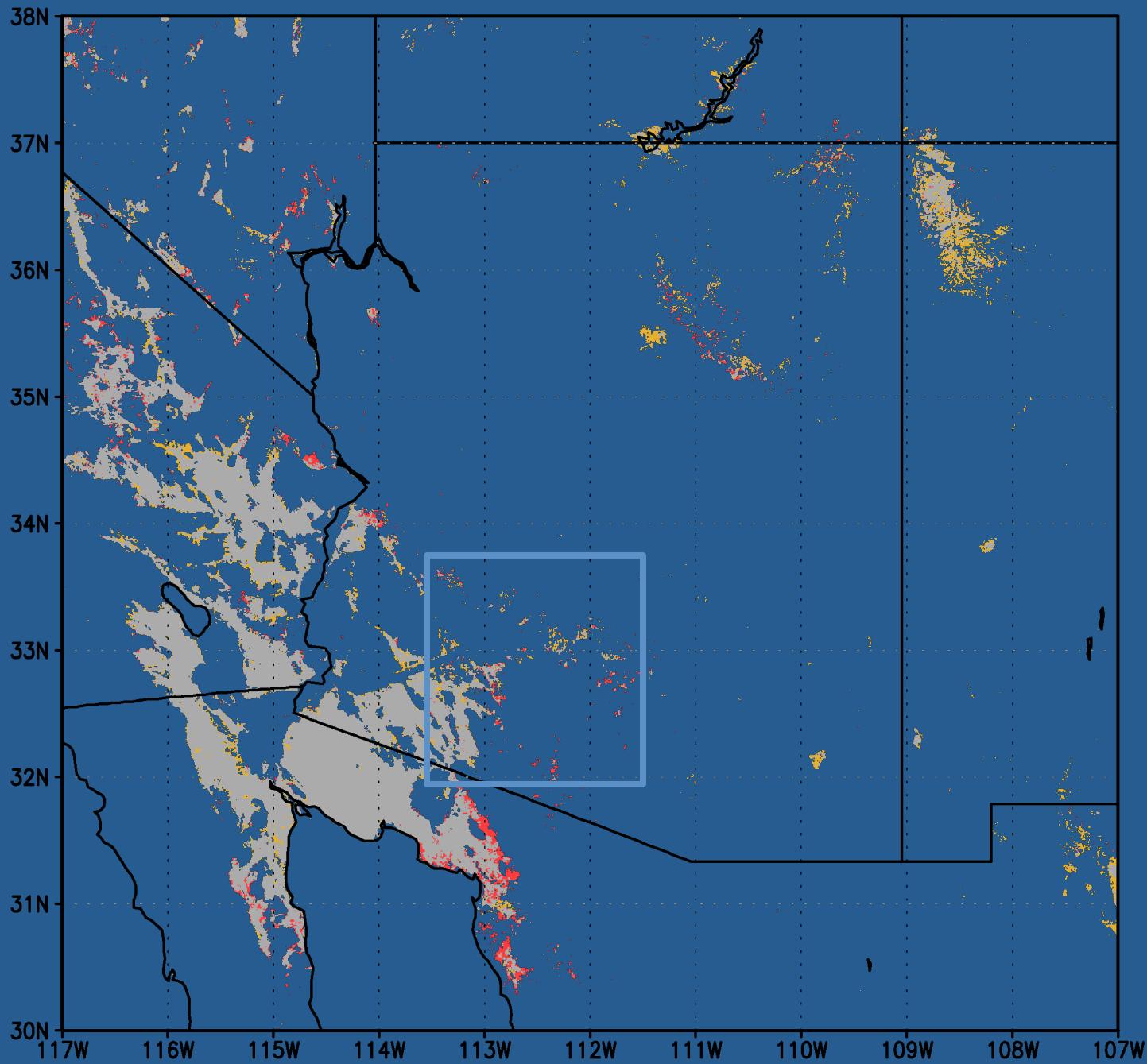
(L) with Olsen land surface data; (R) with NASA MODIS land data: measured (dots) modeled (solid lines) N.B. different scales

For numerical simulation

The dust mask is drawn from NASA satellite observations:

- MCD12Q1: bare + cropland (MODIS Aqua +MODIS Terra)
 - annual land cover, last available for 2009
- MOD13A1: NDVI (MODIS Terra)
 - updated every 16 days

Cropland is updated when $NDVI > 0.25$

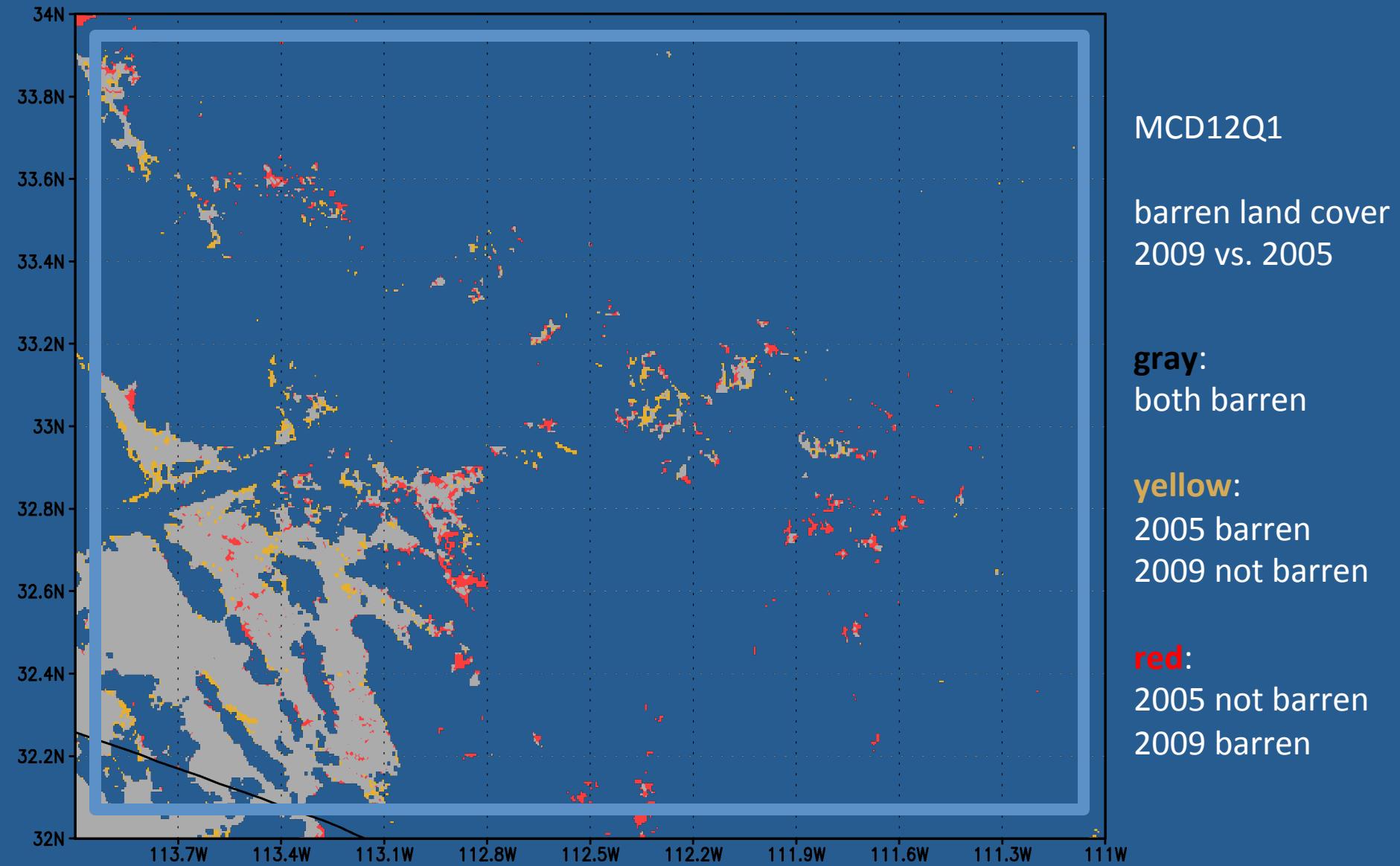


MCD12Q1
barren land cover
2009 vs. 2005

gray:
both barren

yellow:
2005 barren
2009 not barren

red:
2005 not barren
2009 barren



Case Study

5 JULY 2011

CALIFORNIA

MEXICO

ARIZONA

PHOENIX

NEVADA

UTAH

National Weather Service July 2011 Summary



Monsoon activity began in **Arizona** ... following a period of drought. **Strong thunderstorm downdrafts** kicked up dry, loose sand forming a **dust storm 5,000 feet (1500 m) deep moving at up 50 mph (80 kph) and 100 mi (161 km) long** on its leading edge. The dust storm **traveled 150 to 200 miles (241 to 322 km) from Tucson to Phoenix**. Visibility was reduced to between 0 and 5 feet (1.5 m) causing flight delays and interrupting ground travel. Trees and power lines were knocked down but no injuries were reported. Numerous videos captured this visually arresting event.

N.B. ... NM had its driest June on record. AZ its 4th driest.

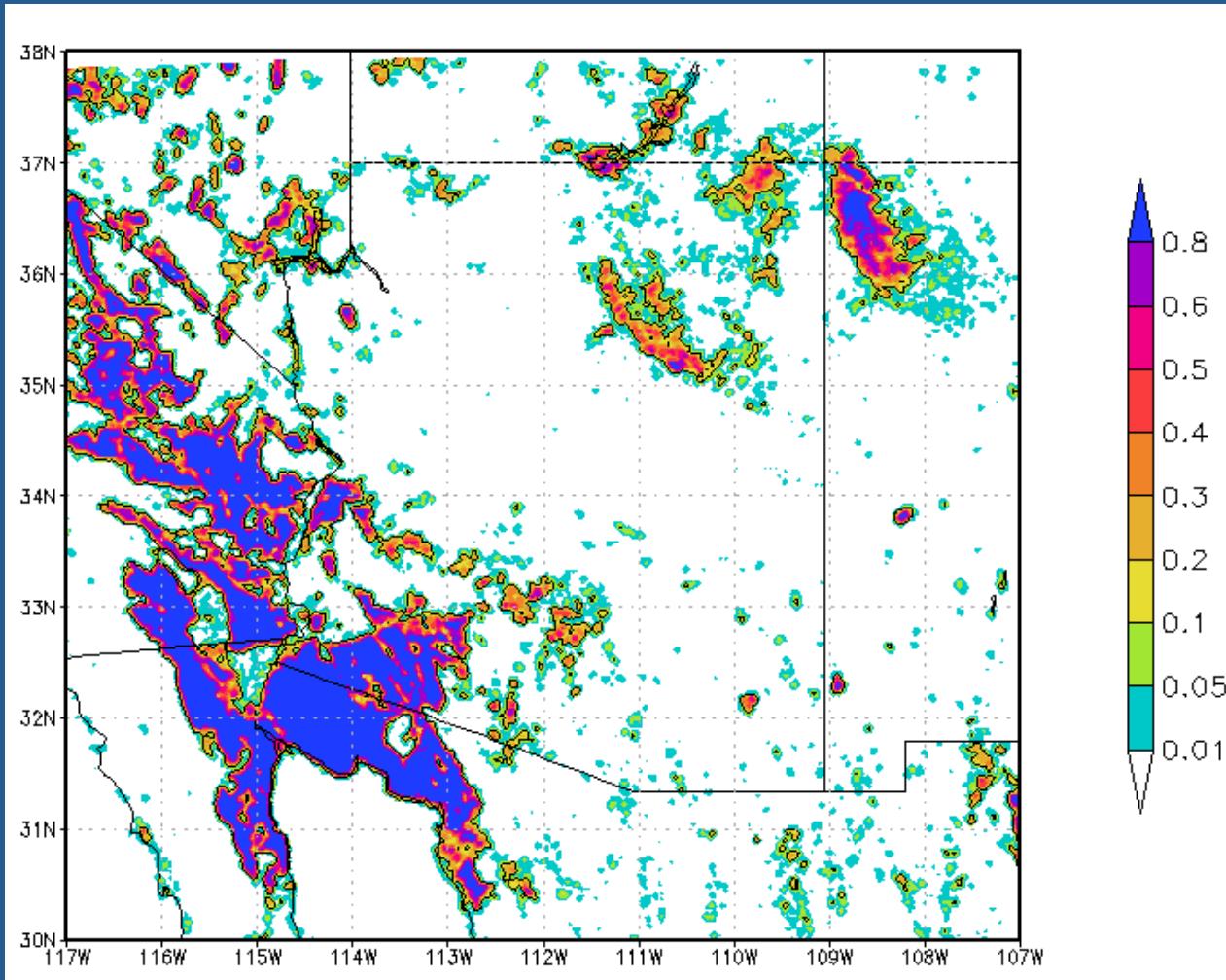
Simulations:

Dust storm evident at 0200h (UTC) July 6th 2011; 6PM (PST) on 5 July 2011 in Phoenix
Phoenix (PST) is 8 hours behind London (UTC)

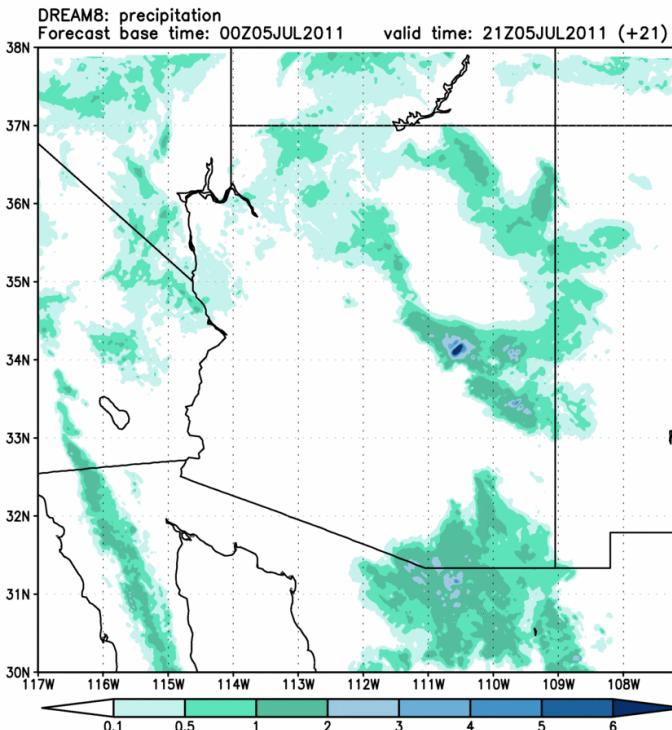
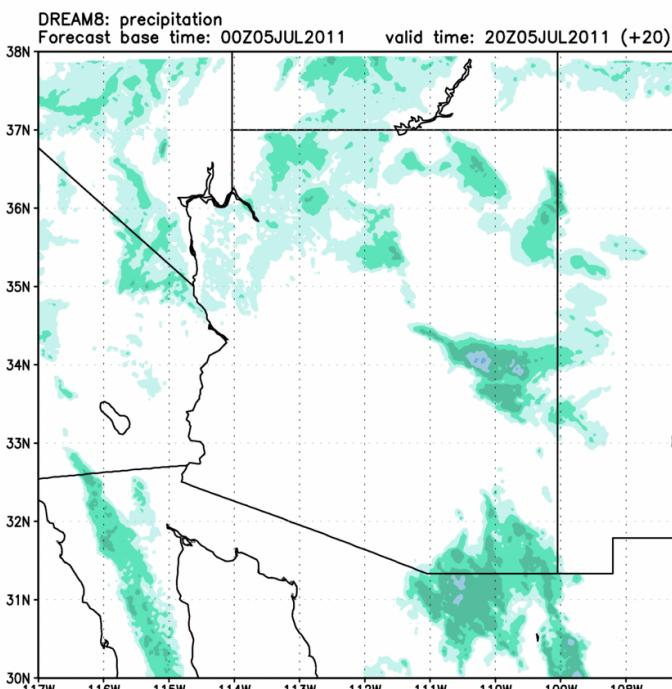
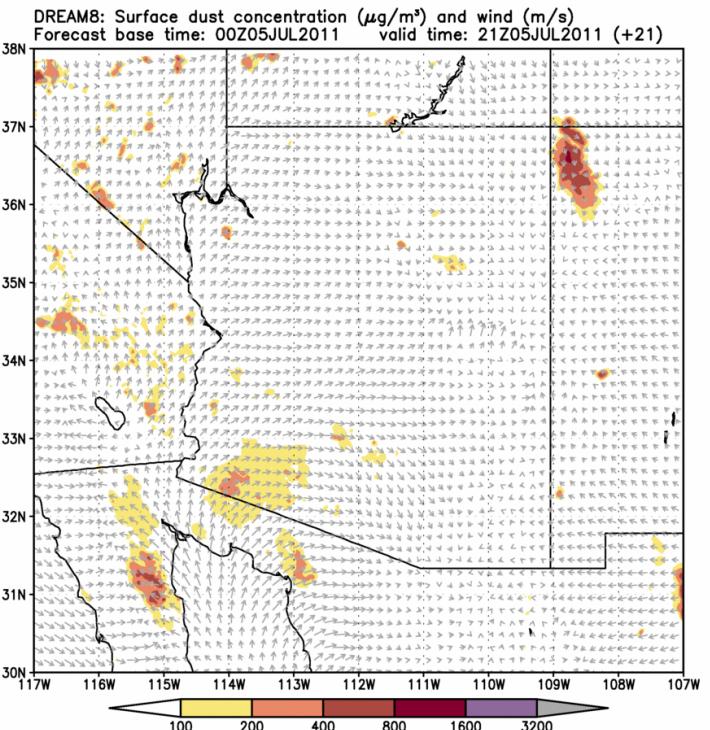
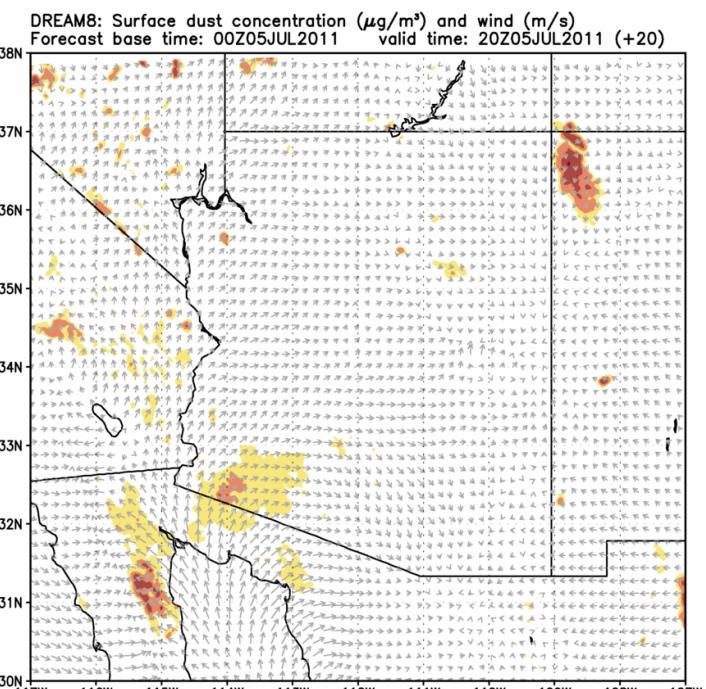
Model: DREAM with NMM atmospheric driver

Simulation: start at July 5th 2011 00UTC +48h “forecast”

Moderate Resolution Imaging Spectroradiometer (MODIS)



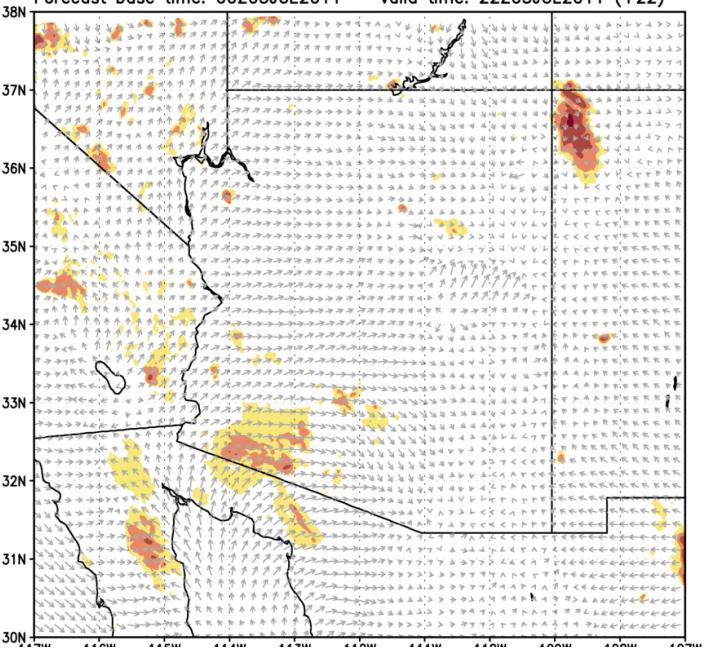
MODIS Combined Data
Resolution: 3.7 km
Mask: MCD12 2009 +
NDVI 04 July 2011



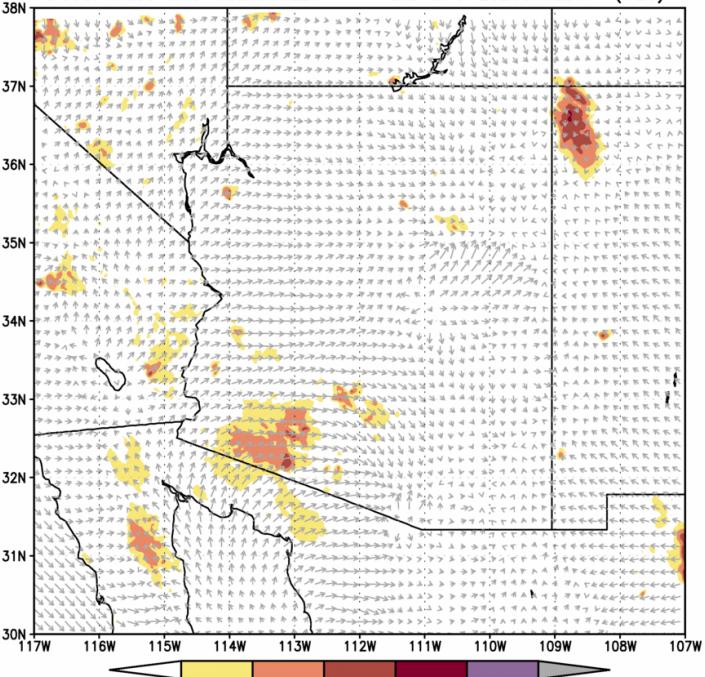
1300 PST

1400 PST

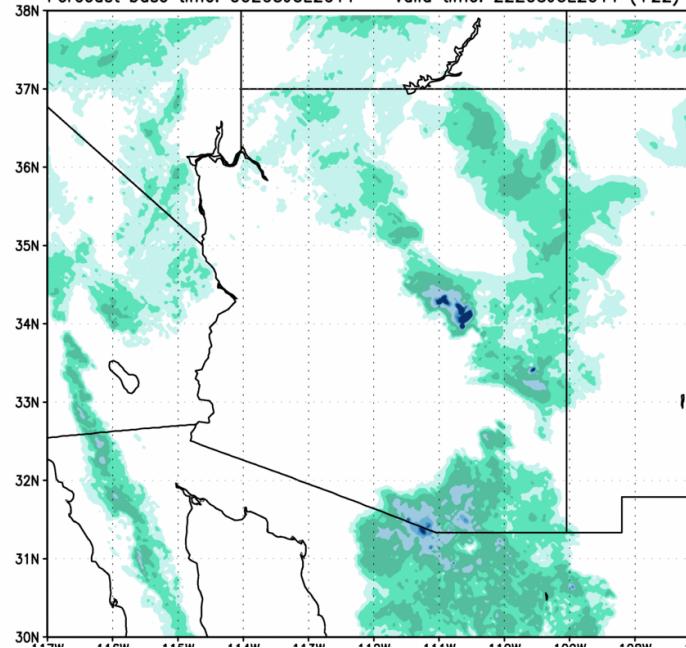
DREAM8: Surface dust concentration ($\mu\text{g}/\text{m}^3$) and wind (m/s)
Forecast base time: 00Z05JUL2011 valid time: 22Z05JUL2011 (+22)



DREAM8: Surface dust concentration ($\mu\text{g}/\text{m}^3$) and wind (m/s)
Forecast base time: 00Z05JUL2011 valid time: 23Z05JUL2011 (+23)

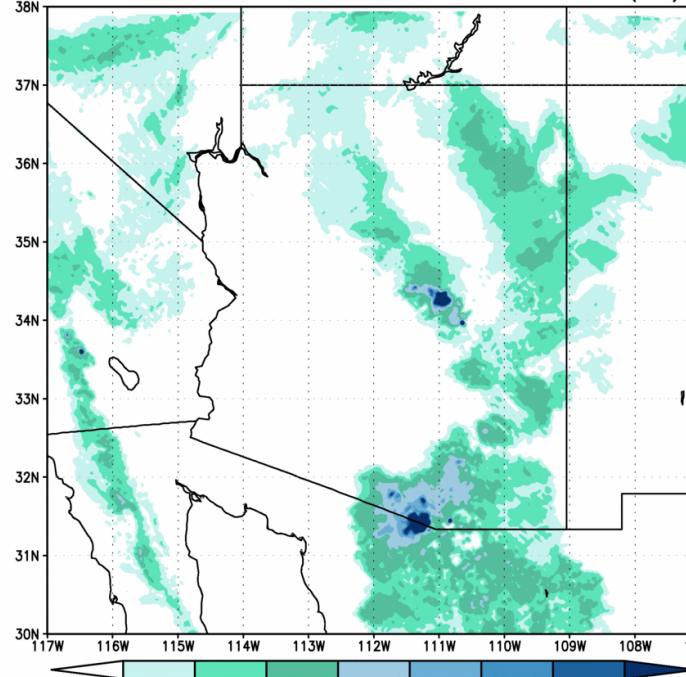


DREAM8: precipitation
Forecast base time: 00Z05JUL2011 valid time: 22Z05JUL2011 (+22)

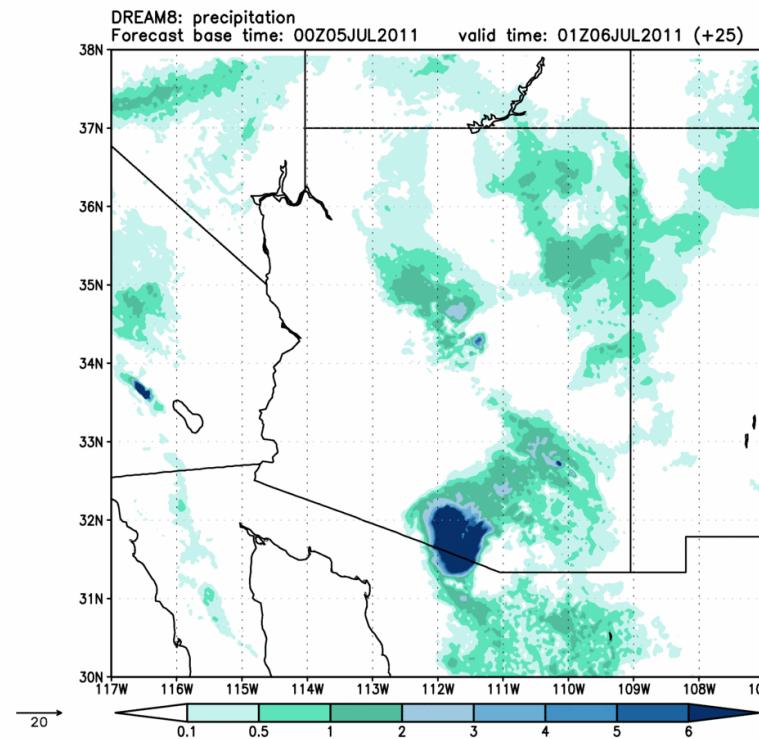
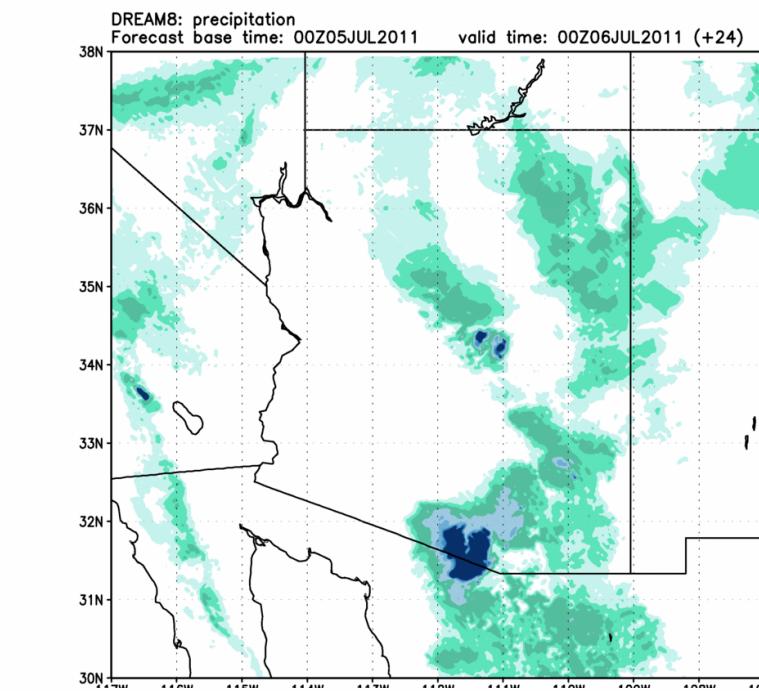
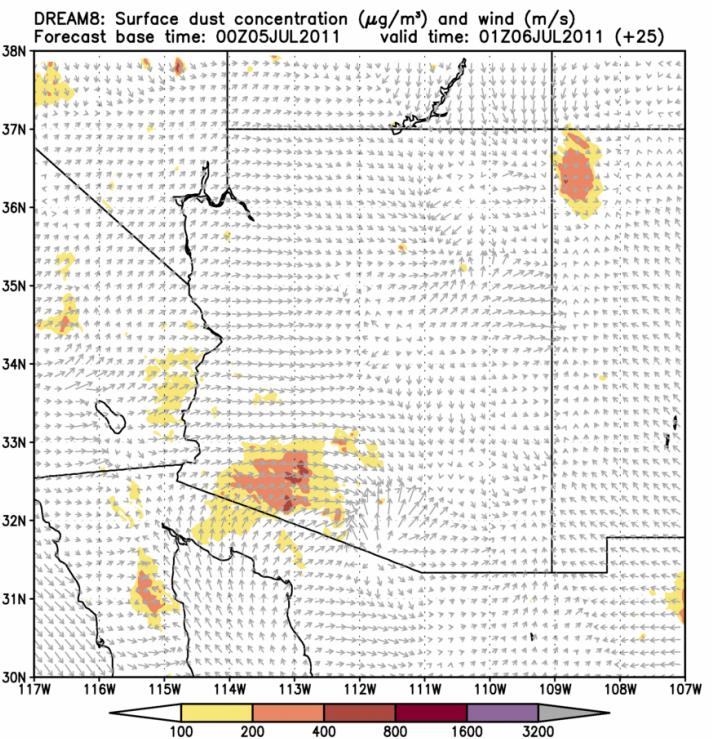
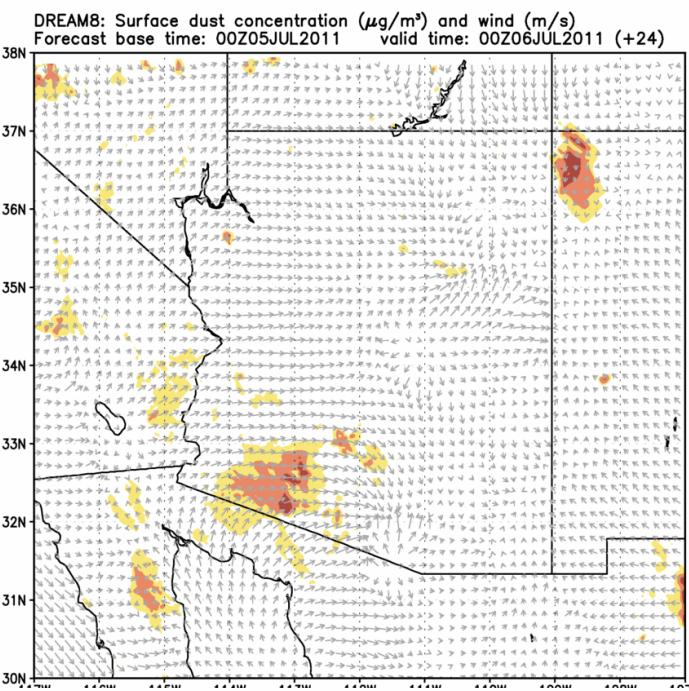


1500 PST

DREAM8: precipitation
Forecast base time: 00Z05JUL2011 valid time: 23Z05JUL2011 (+23)



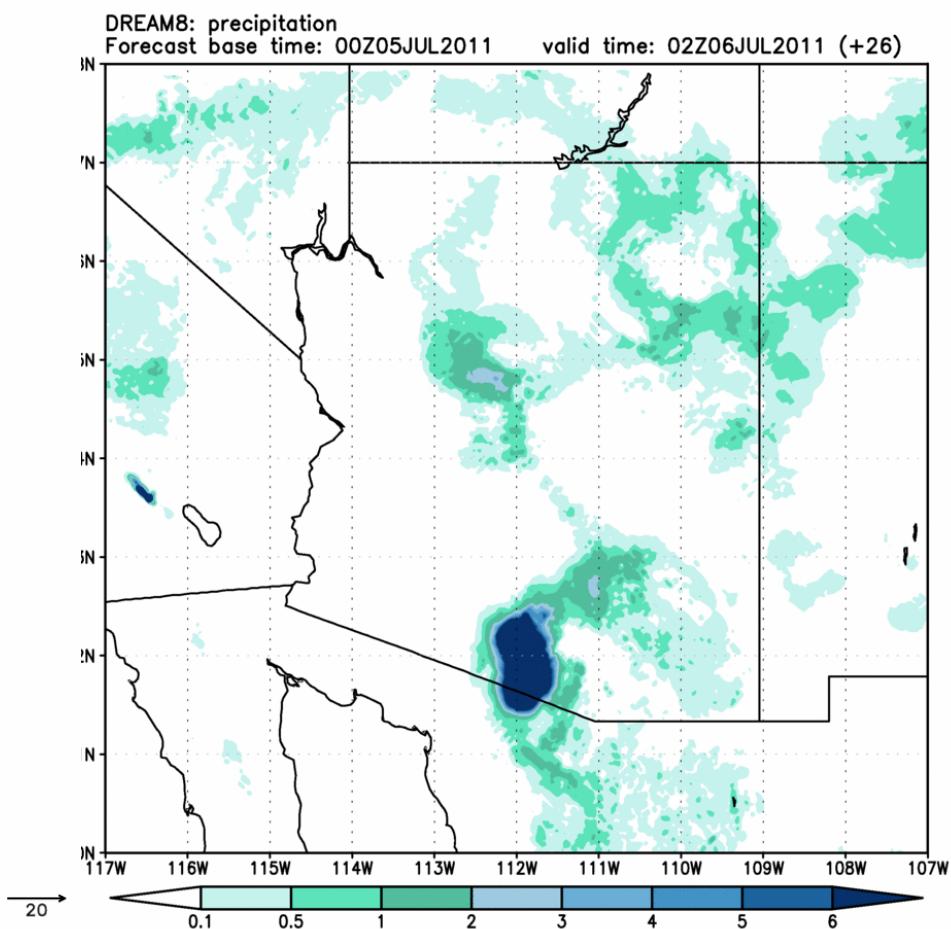
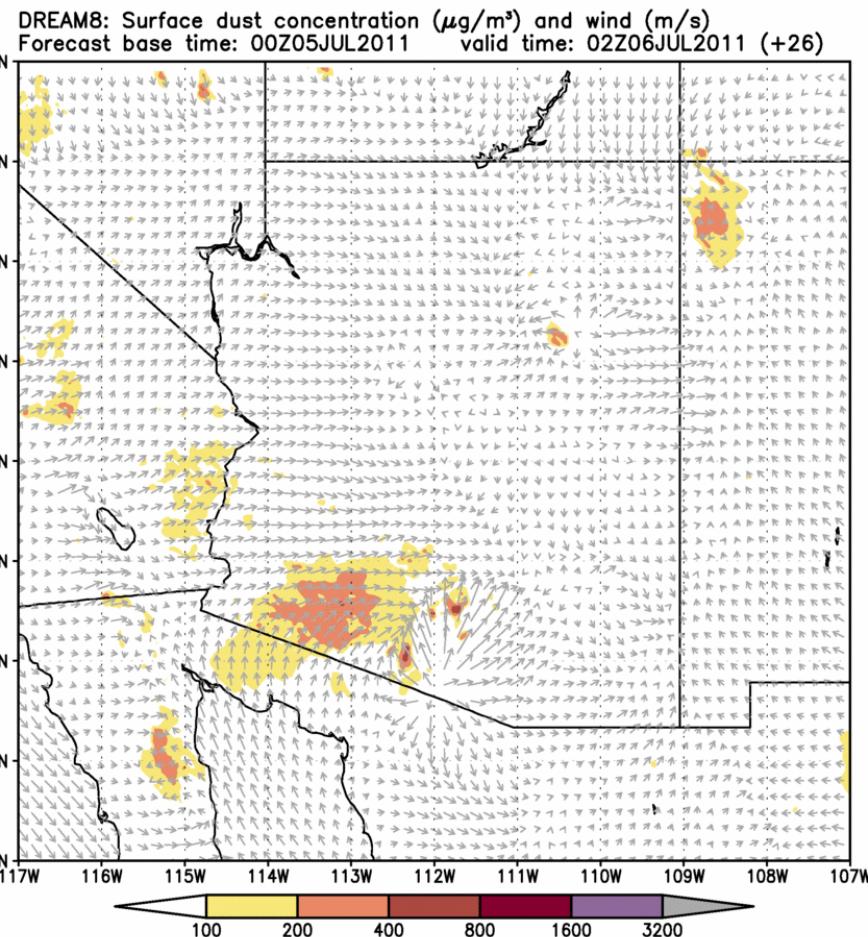
1600 PST



1700 PST

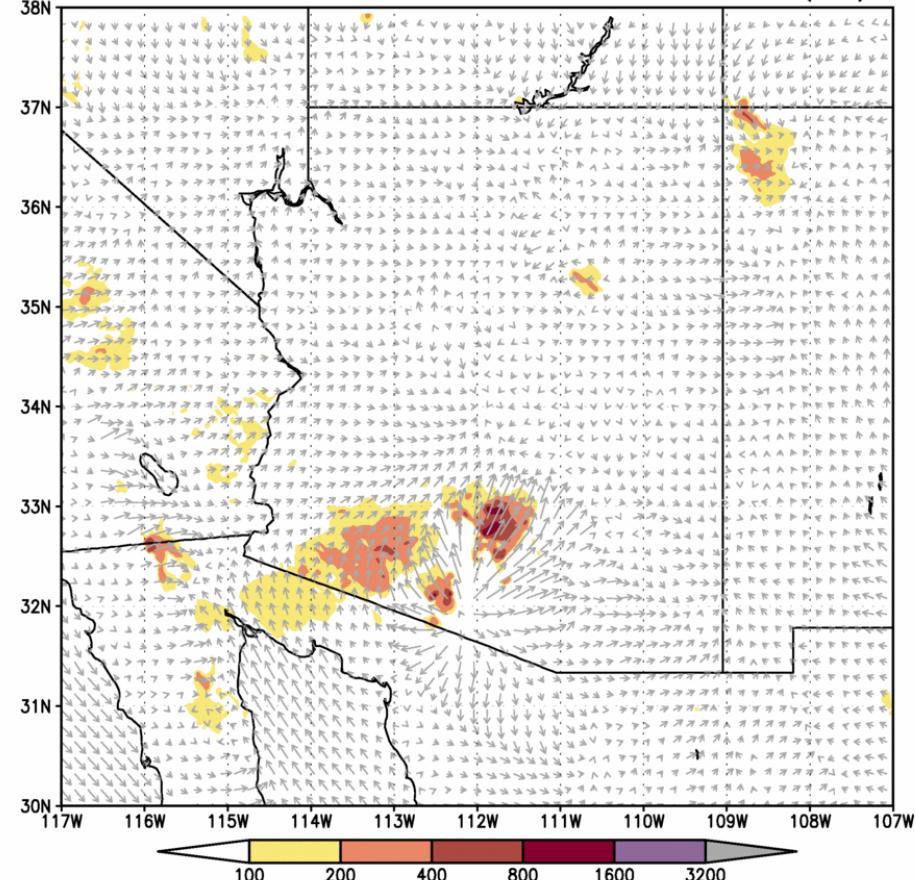
1800 PST

1900 PST - AZ time

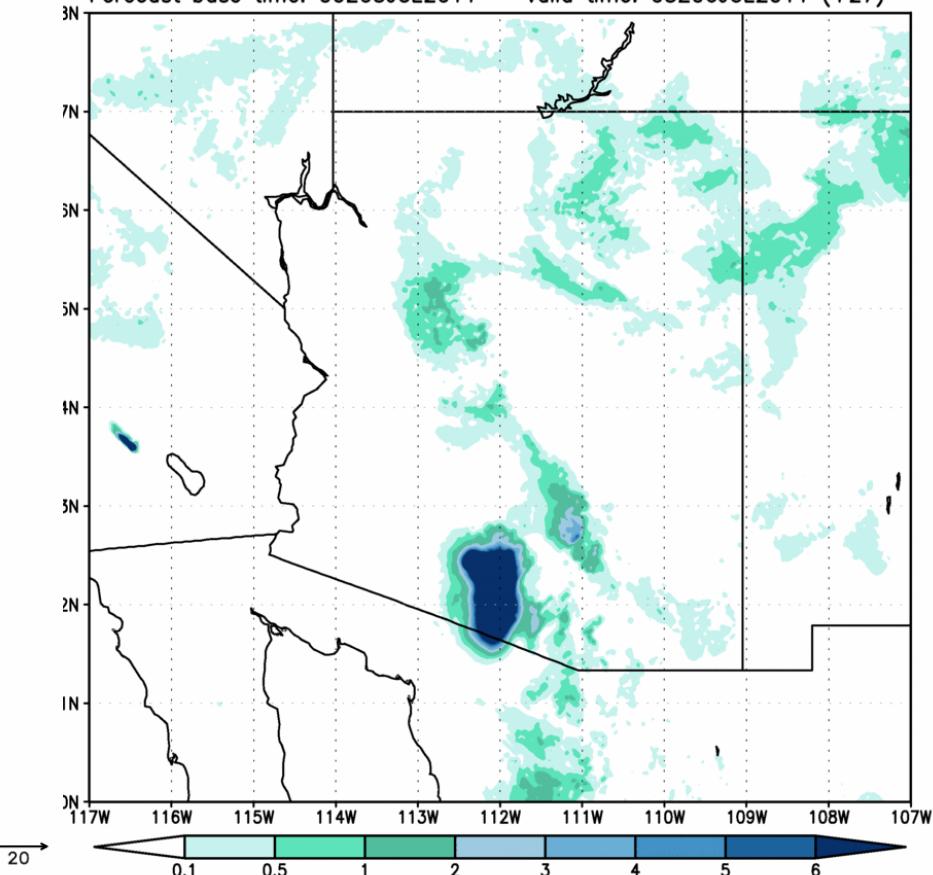


2000 PST - AZ time

DREAM8: Surface dust concentration ($\mu\text{g}/\text{m}^3$) and wind (m/s)
Forecast base time: 00Z05JUL2011 valid time: 03Z06JUL2011 (+27)

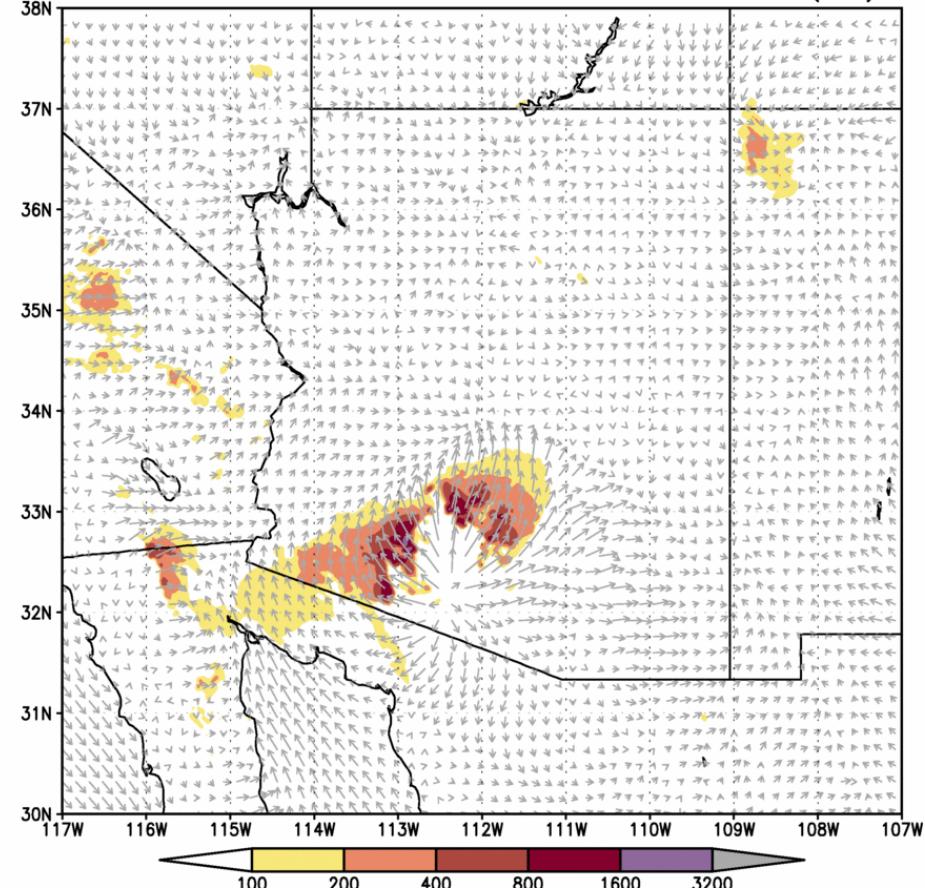


DREAM8: precipitation
Forecast base time: 00Z05JUL2011 valid time: 03Z06JUL2011 (+27)

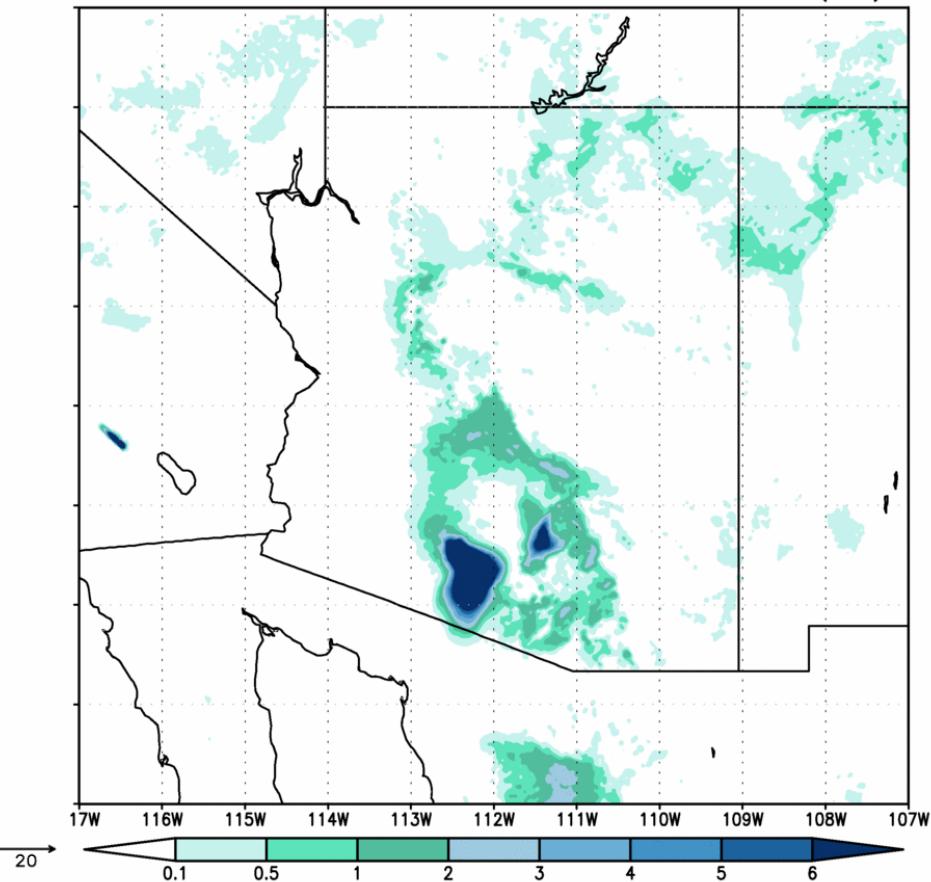


2100 PST - AZ time

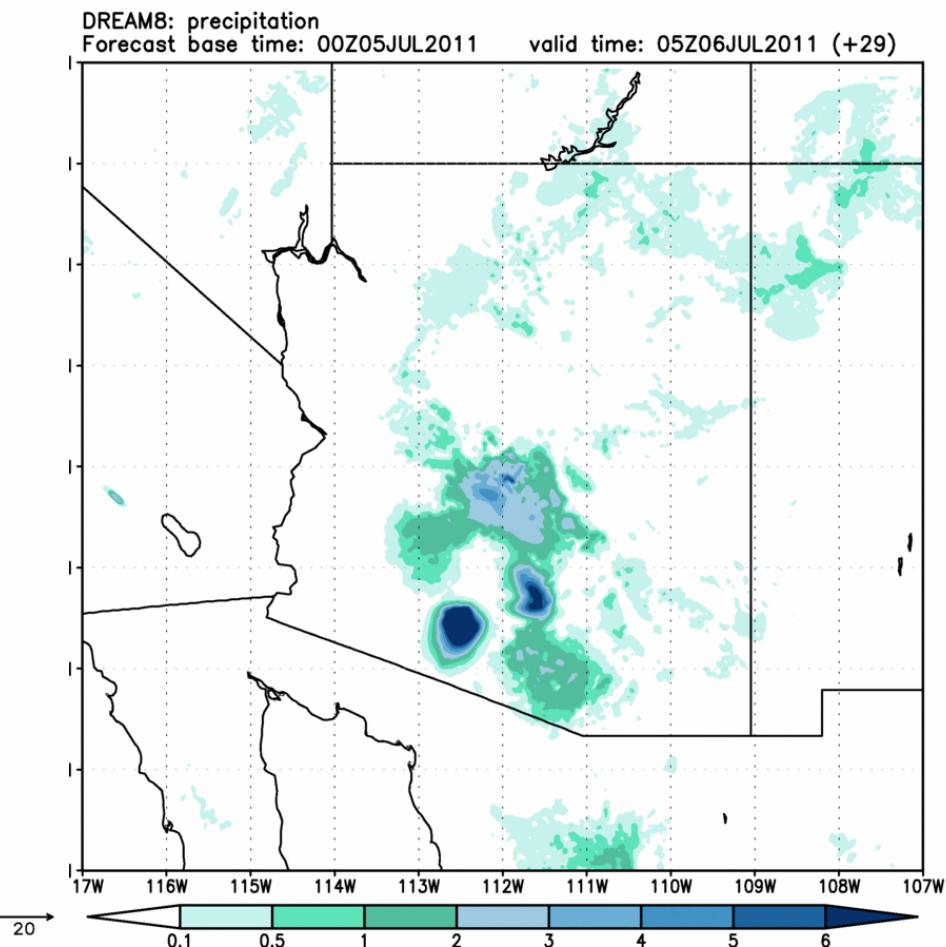
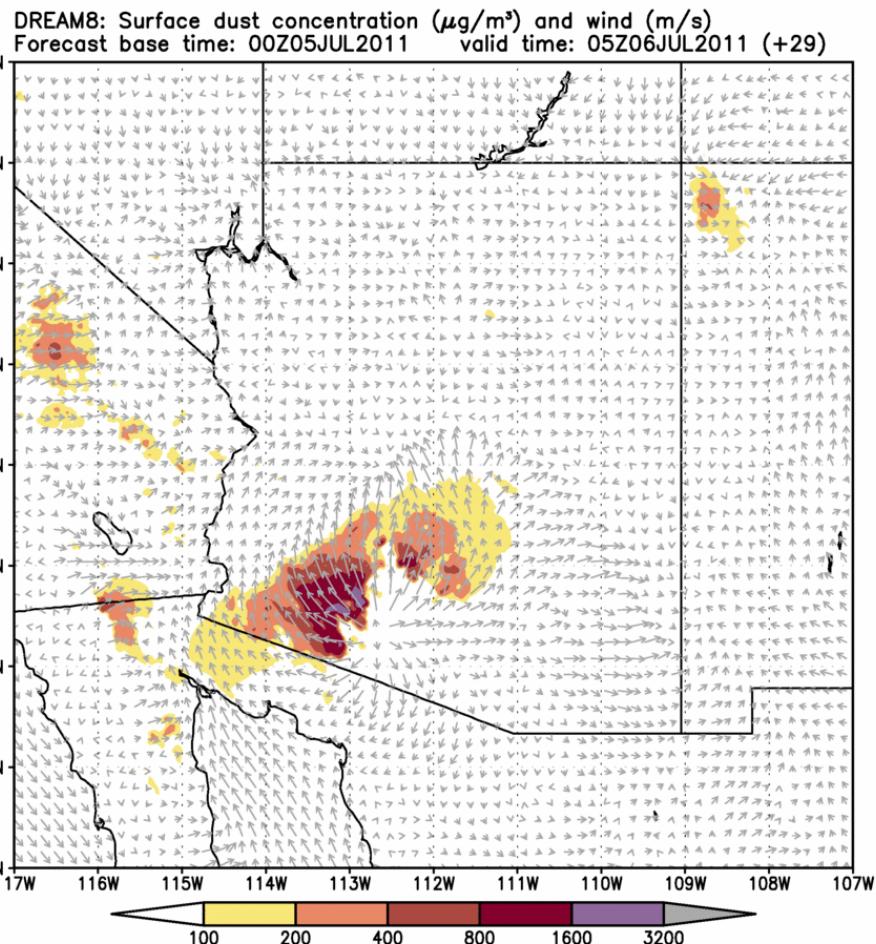
DREAM8: Surface dust concentration ($\mu\text{g}/\text{m}^3$) and wind (m/s)
Forecast base time: 00Z05JUL2011 valid time: 04Z06JUL2011 (+28)



DREAM8: precipitation
Forecast base time: 00Z05JUL2011 valid time: 04Z06JUL2011 (+28)

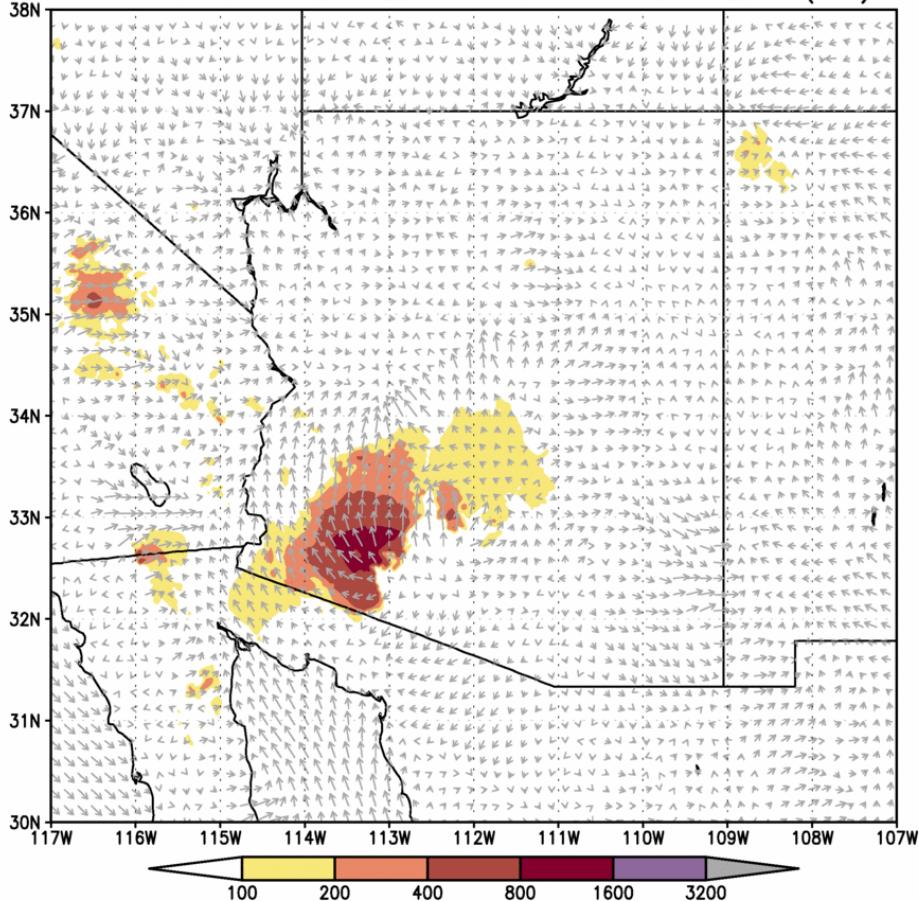


2200 PST - AZ time

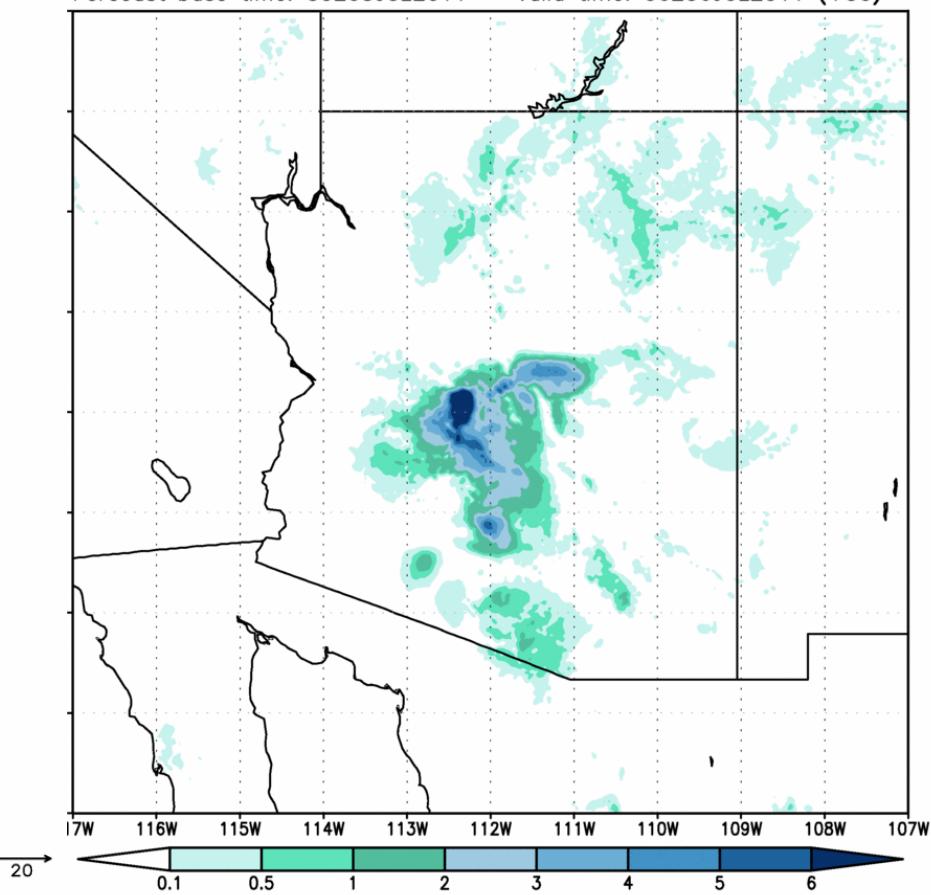


2300 PST - AZ time

DREAM8: Surface dust concentration ($\mu\text{g}/\text{m}^3$) and wind (m/s)
Forecast base time: 00Z05JUL2011 valid time: 06Z06JUL2011 (+30)

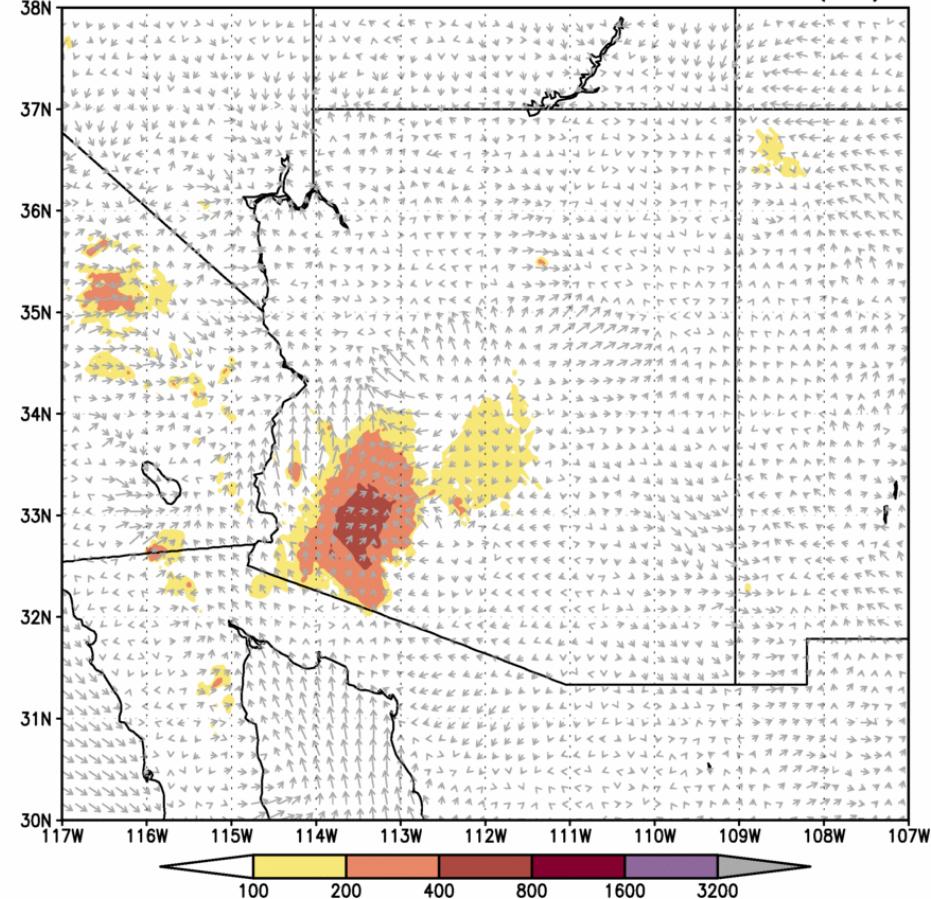


DREAM8: precipitation
Forecast base time: 00Z05JUL2011 valid time: 06Z06JUL2011 (+30)

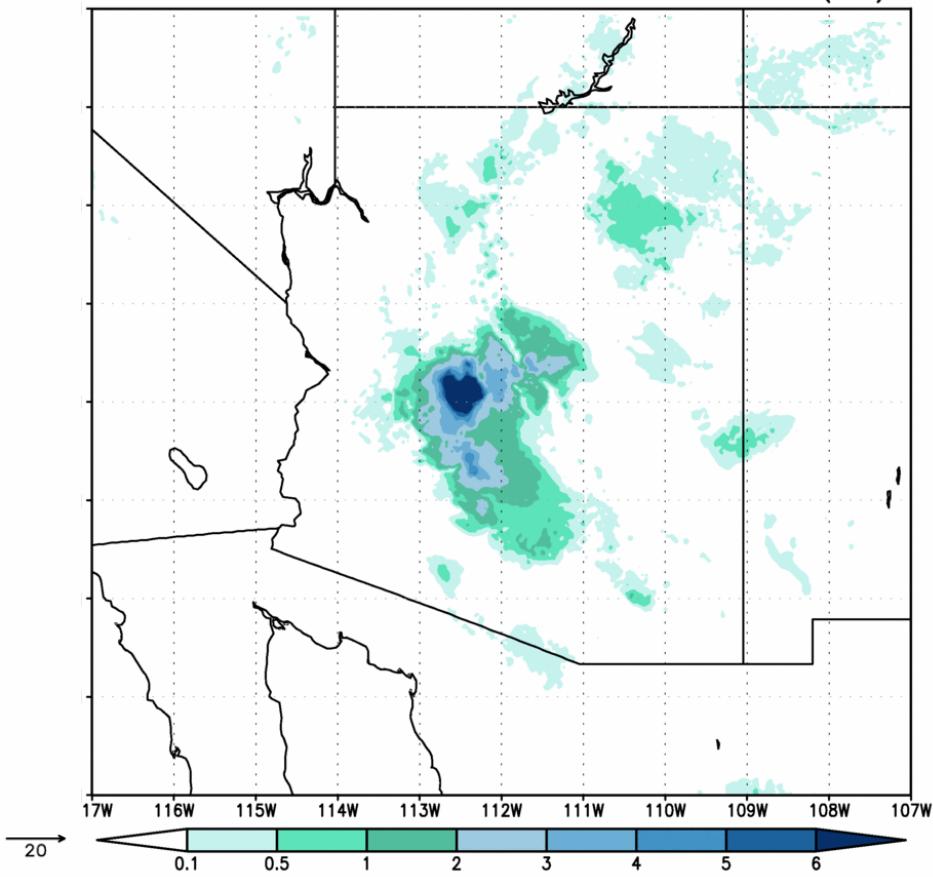


0000 PST - AZ time

DREAM8: Surface dust concentration ($\mu\text{g}/\text{m}^3$) and wind (m/s)
Forecast base time: 00Z05JUL2011 valid time: 07Z06JUL2011 (+31)



DREAM8: precipitation
Forecast base time: 00Z05JUL2011 valid time: 07Z06JUL2011 (+31)



Surface dust concentration lat=33N

2200 PST

2100 PST

2000 PST

1900 PST

1800 PST

1700 PST

Concentration ($\mu\text{g}/\text{m}^3$)

06Z06JUL2011

05Z06JUL2011

04Z06JUL2011

03Z06JUL2011

02Z06JUL2011

01Z06JUL2011

00Z06JUL2011

113.7W

113.4W

113.1W

112.8W

112.5W

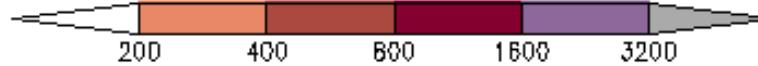
112.2W

111.9W

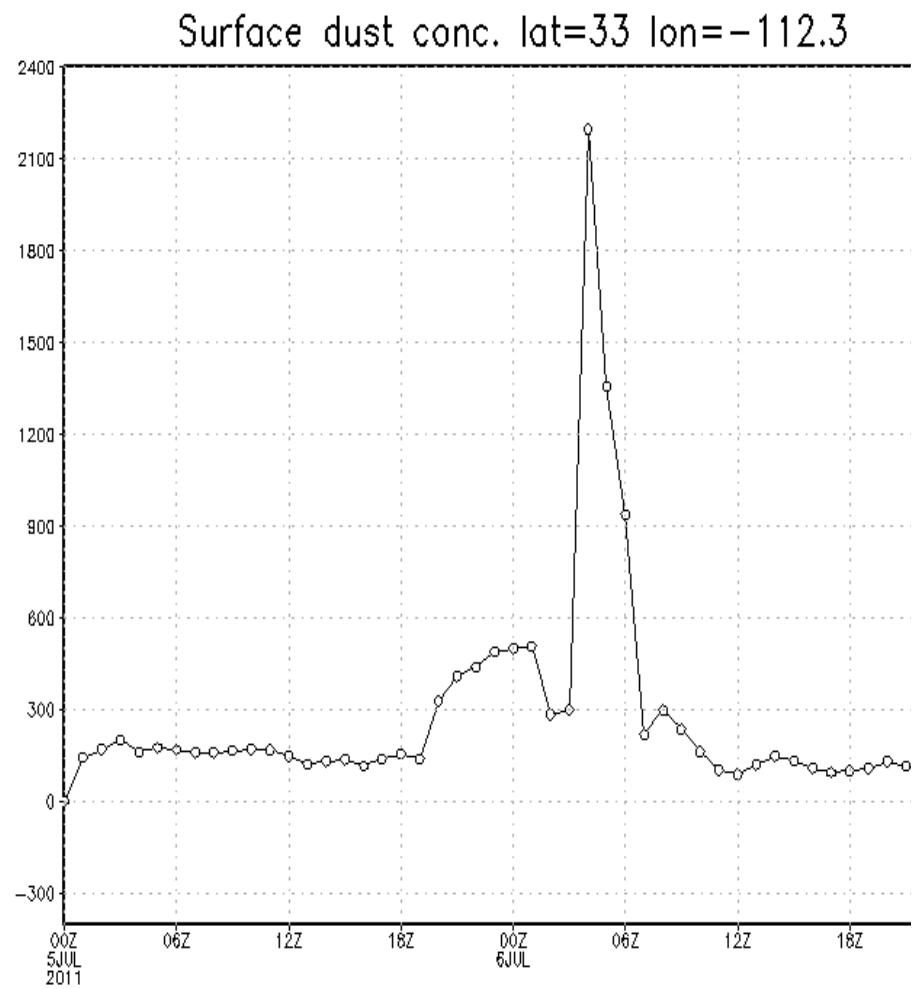
111.6W

111.3W

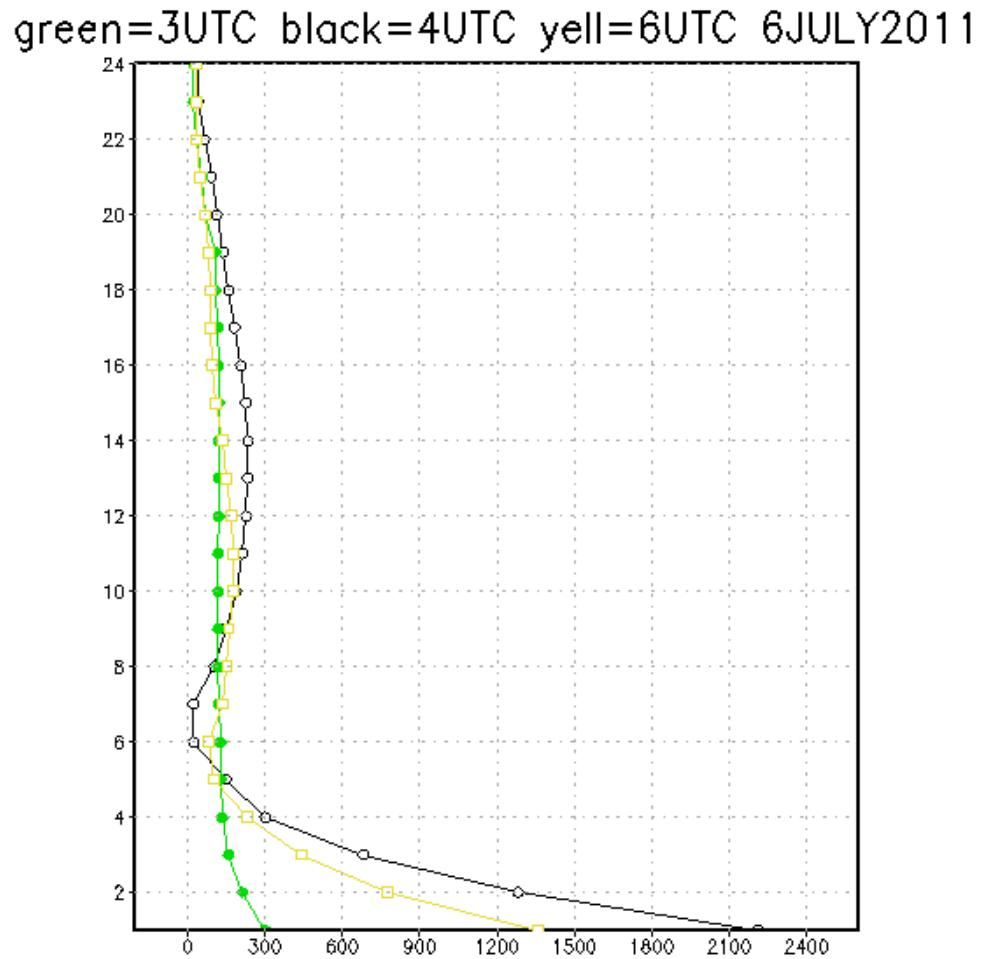
111W



Concentration ($\mu\text{g}/\text{m}^3$) vs Time



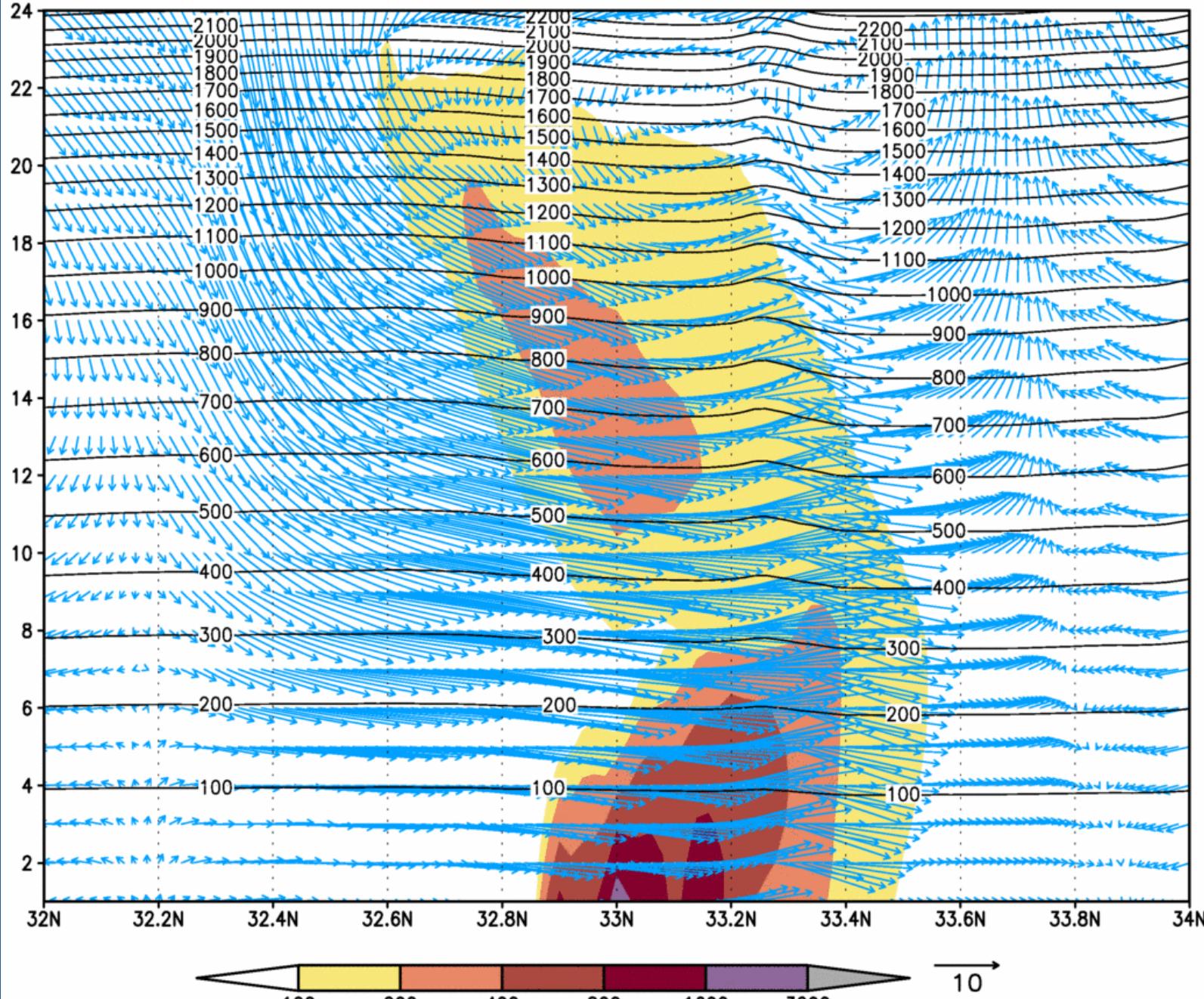
Concentration ($\mu\text{g}/\text{m}^3$) vs Height



2100 PST

~2000m

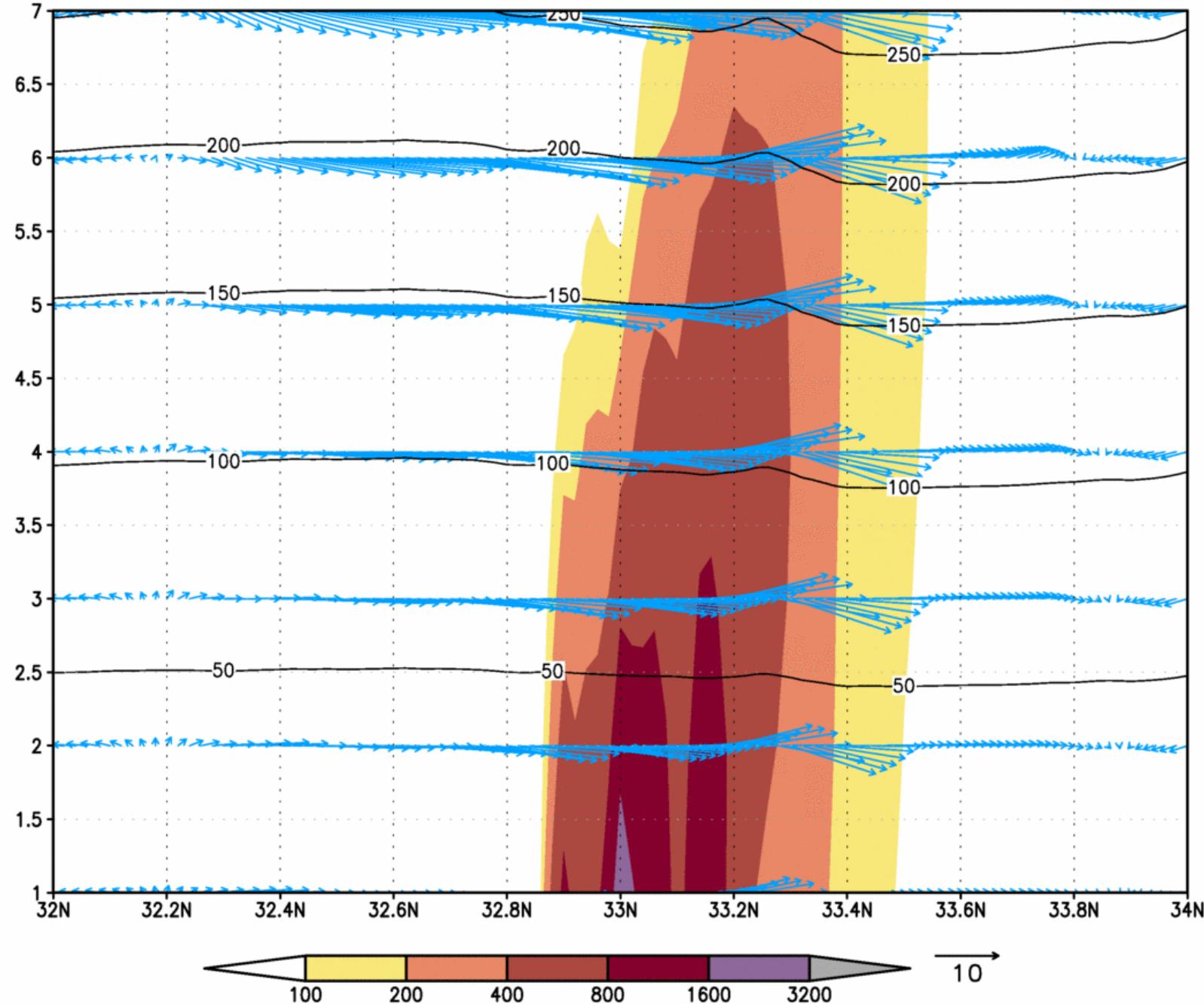
Concentration ($\mu\text{g}/\text{m}^3$) hgt, wind ($v \times w$) lon=-112.3



2100 PST

Concentration ($\mu\text{g}/\text{m}^3$) hgt, wind ($v \times w$) lon=-112.3

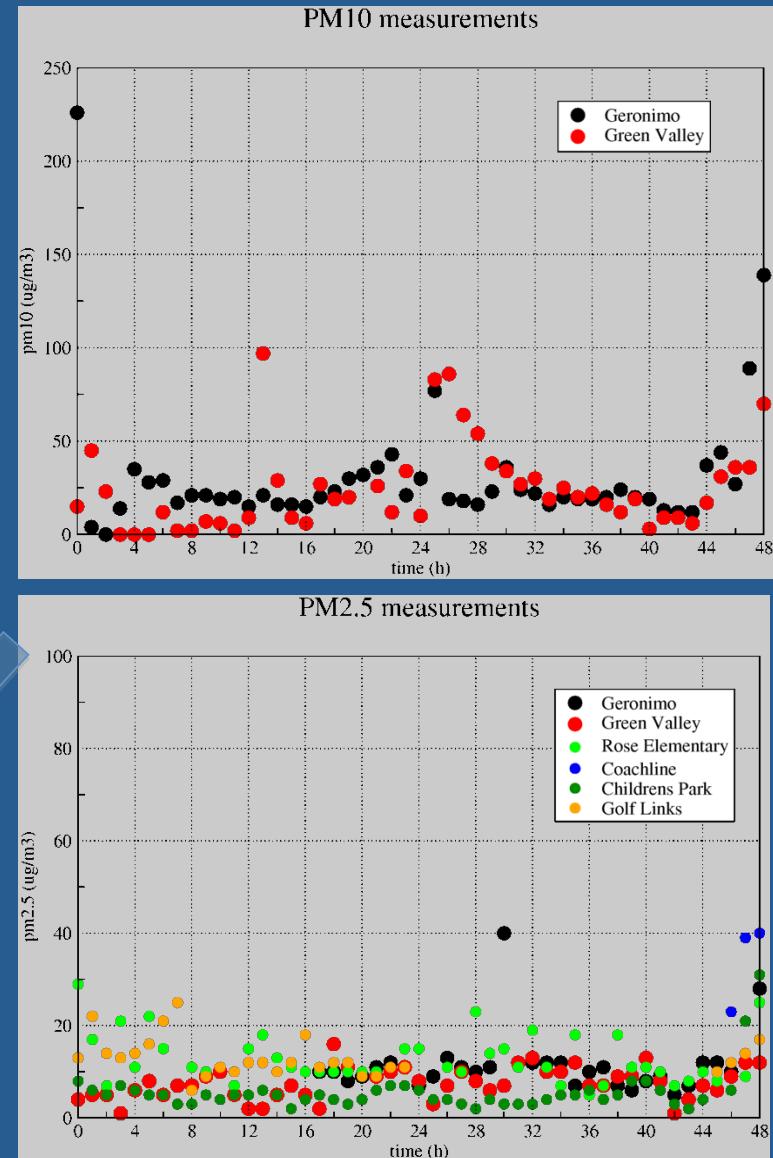
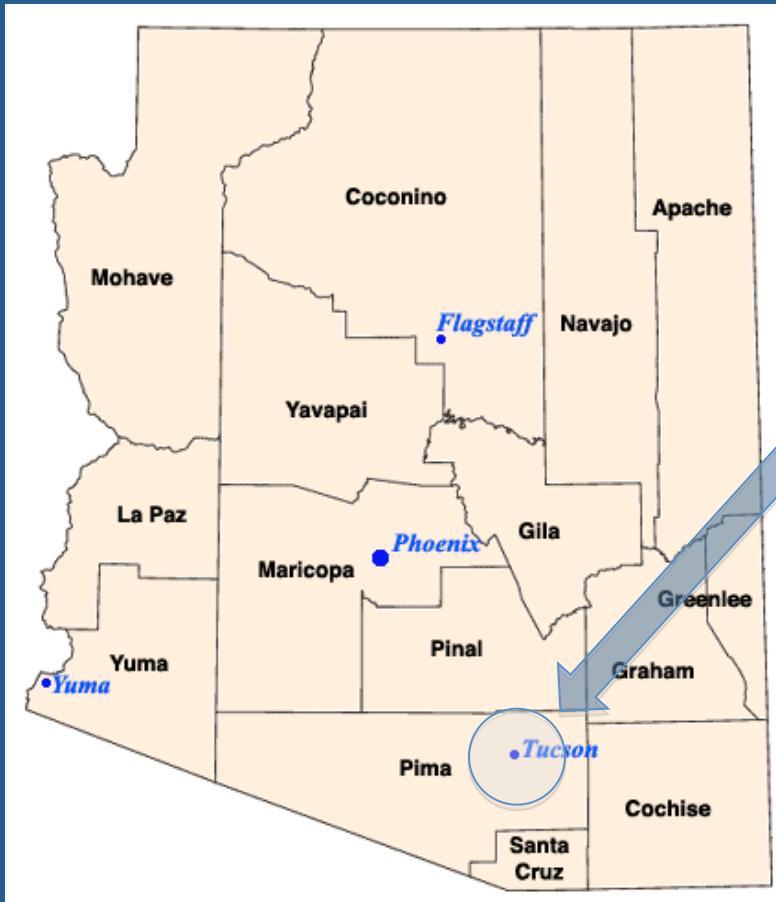
~200m



Model Verification

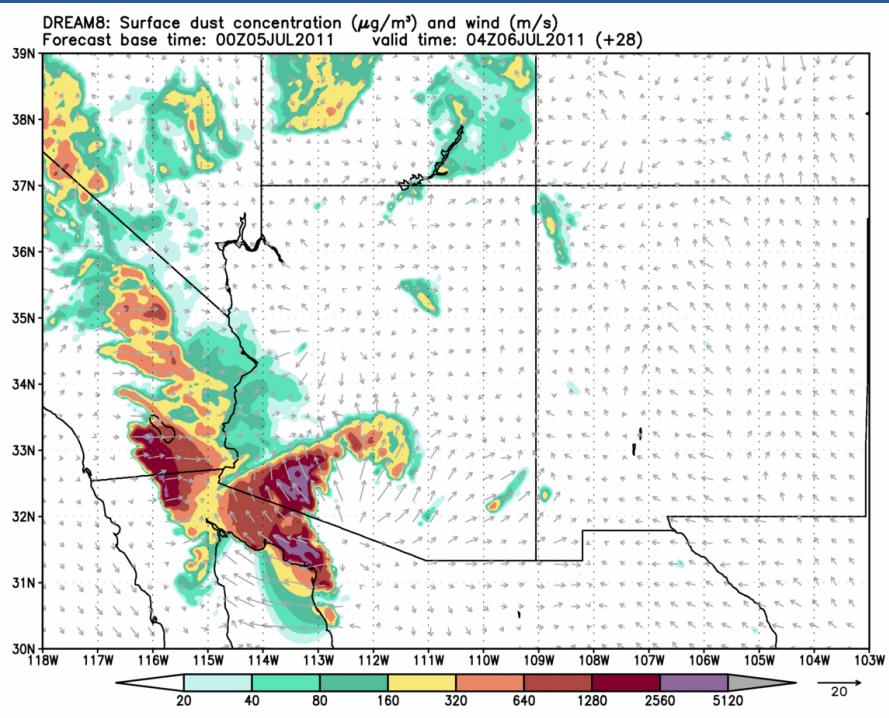
PM measurements – we have Pima County
(problem: need hourly Pinal & Maricopa counties' data)

Wind measurements – AZMET available
(problem: need hourly data but only hourly max and averages available)

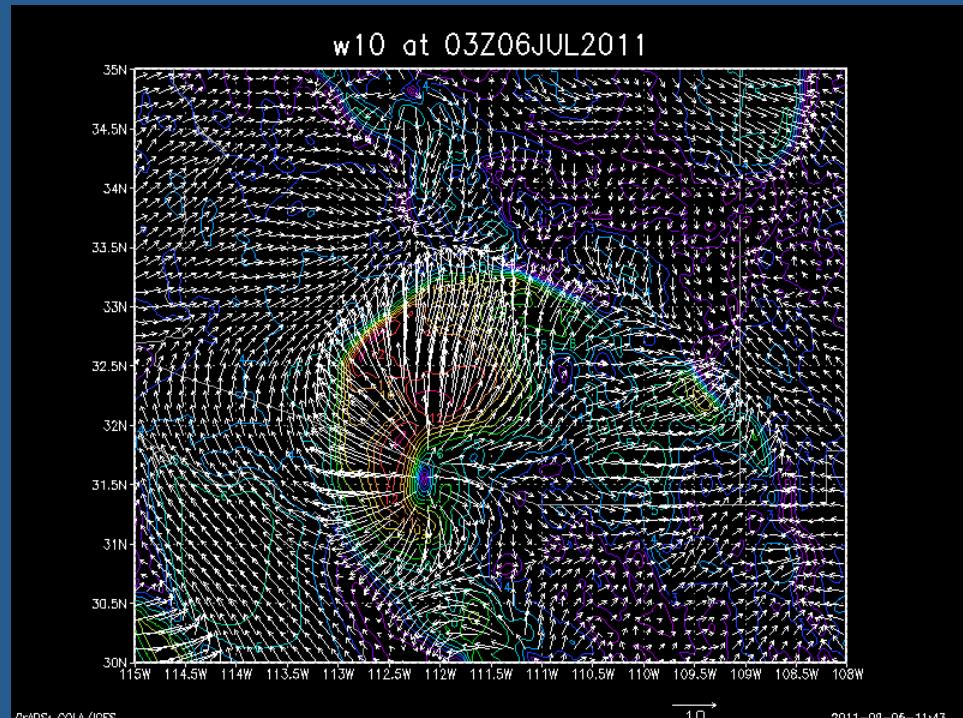


Forecast Diagnostics: Wind

Dust 28-hour “forecast” showing haboob –
6 km horizontal resolution

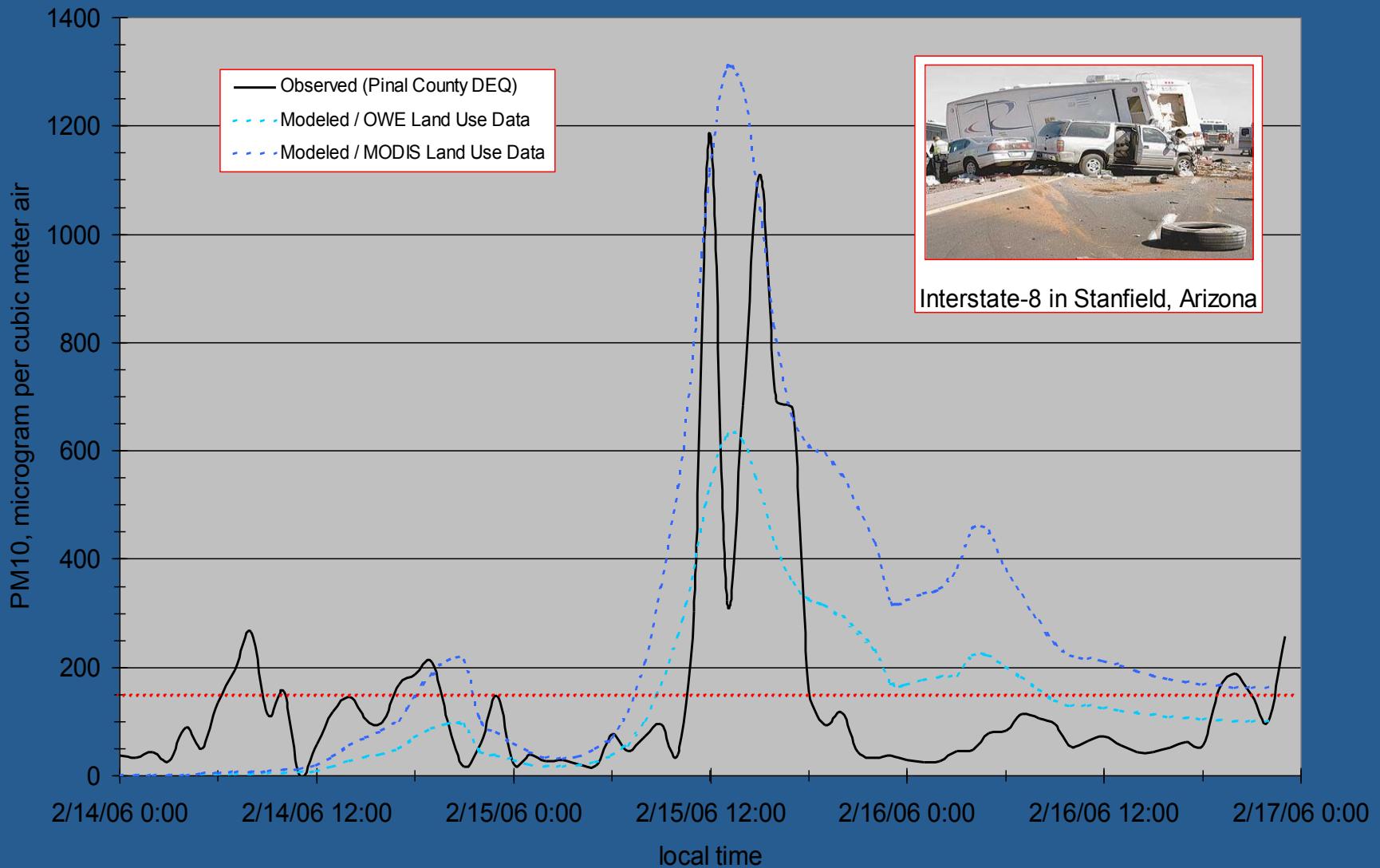


Wind magnitude and stream function --
3.5 Km Horizontal resolution



15-16 February 2006

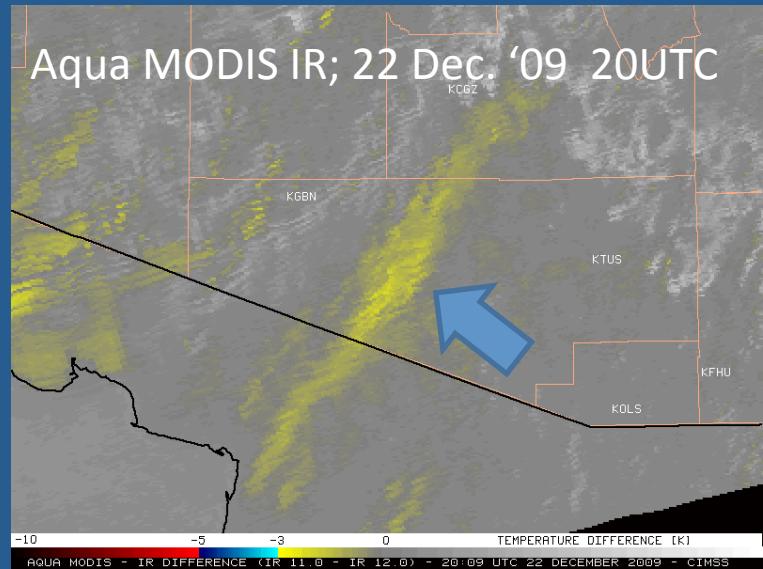
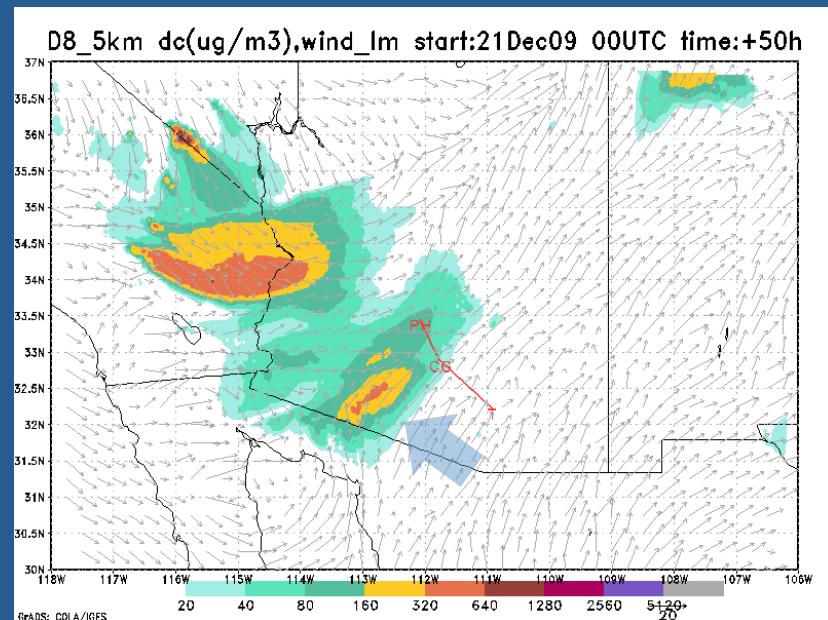
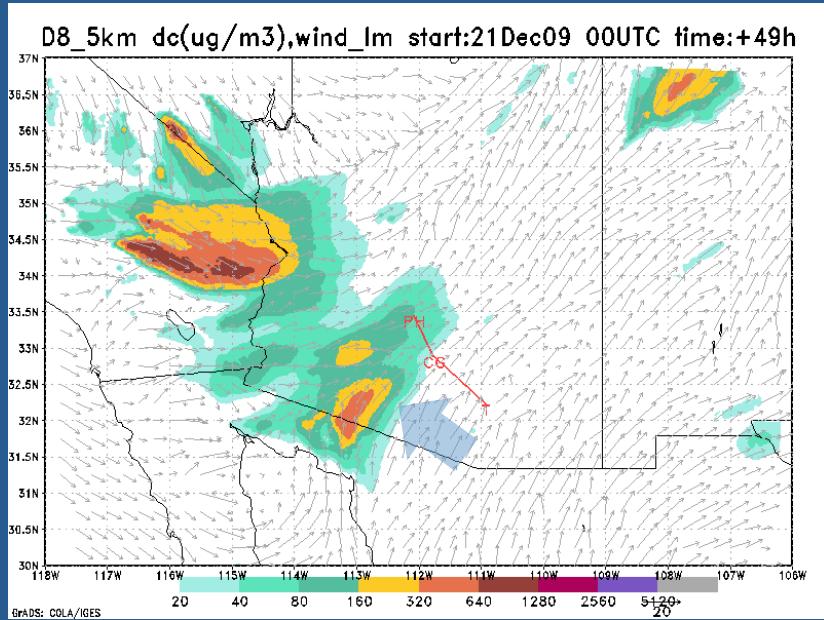
SOUTHWEST UNITED STATES



22 DECEMBER 2009

SOUTHWEST UNITED STATES

Dust Storm Forecast 49 hrs (L) 50 hrs (R) _ 22 December 2009



ACKNOWLEDGEMENTS

- Dr. Slobodan Nickovic (WMO) for DREAM
- Ana Vukovic & Mirjam Vujadinovic (University of Belgrade), Goran Pejanovic (Serbia Met Service) model operations
- Dr. Zavisa Janjic (NOAA/NWS/NCEP) for NMM
- Tom Budge (UNM EDAC) MODIS-derived dust masks
- UA Supercomputing Center
- Dr. Anup Prasad (Chapman University) satellite data analyses
- NASA Applied Sciences Program (Human Health) grant



A Proxy for Cocci: Airborne Dust

Modeling Airborne Desert Dust



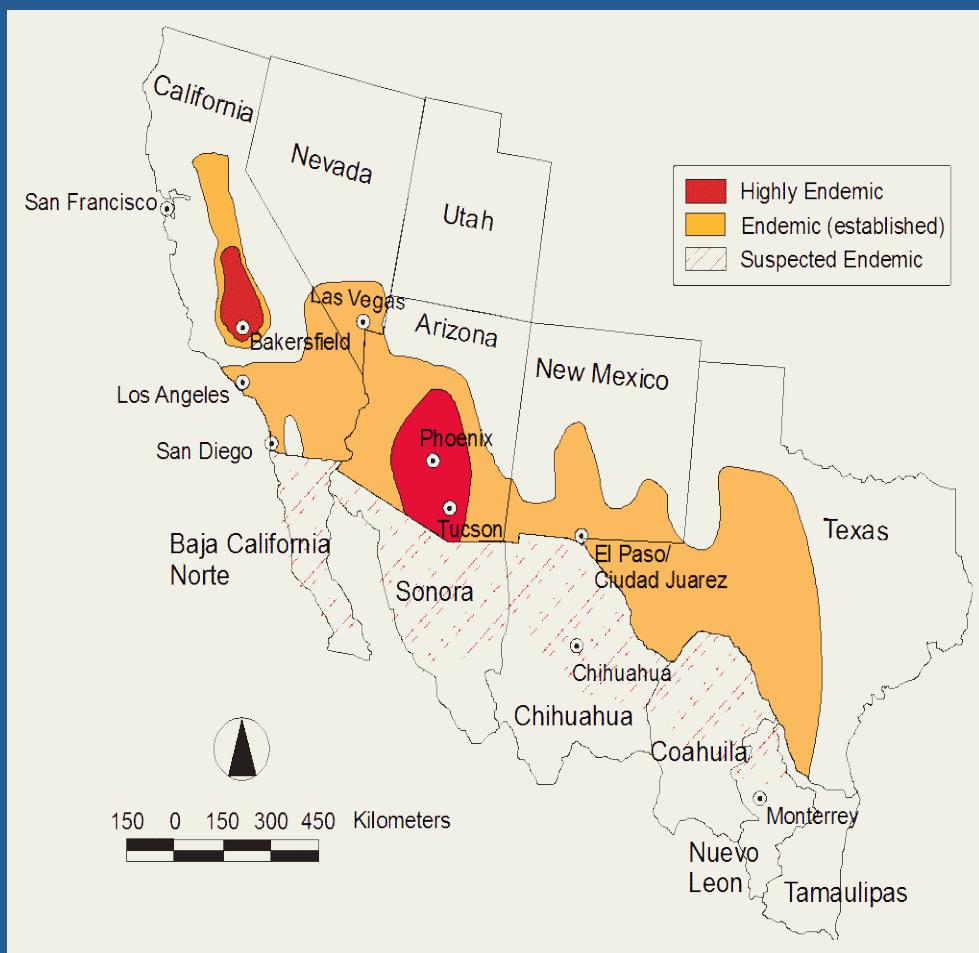
Phoenix, Monday Evening, July 18, 2011

Dust wall 3,000 feet high; winds 25 to 40 mph

AP Photo/The Arizona Republic, Nick Oza



Valley Fever Endemic Zone

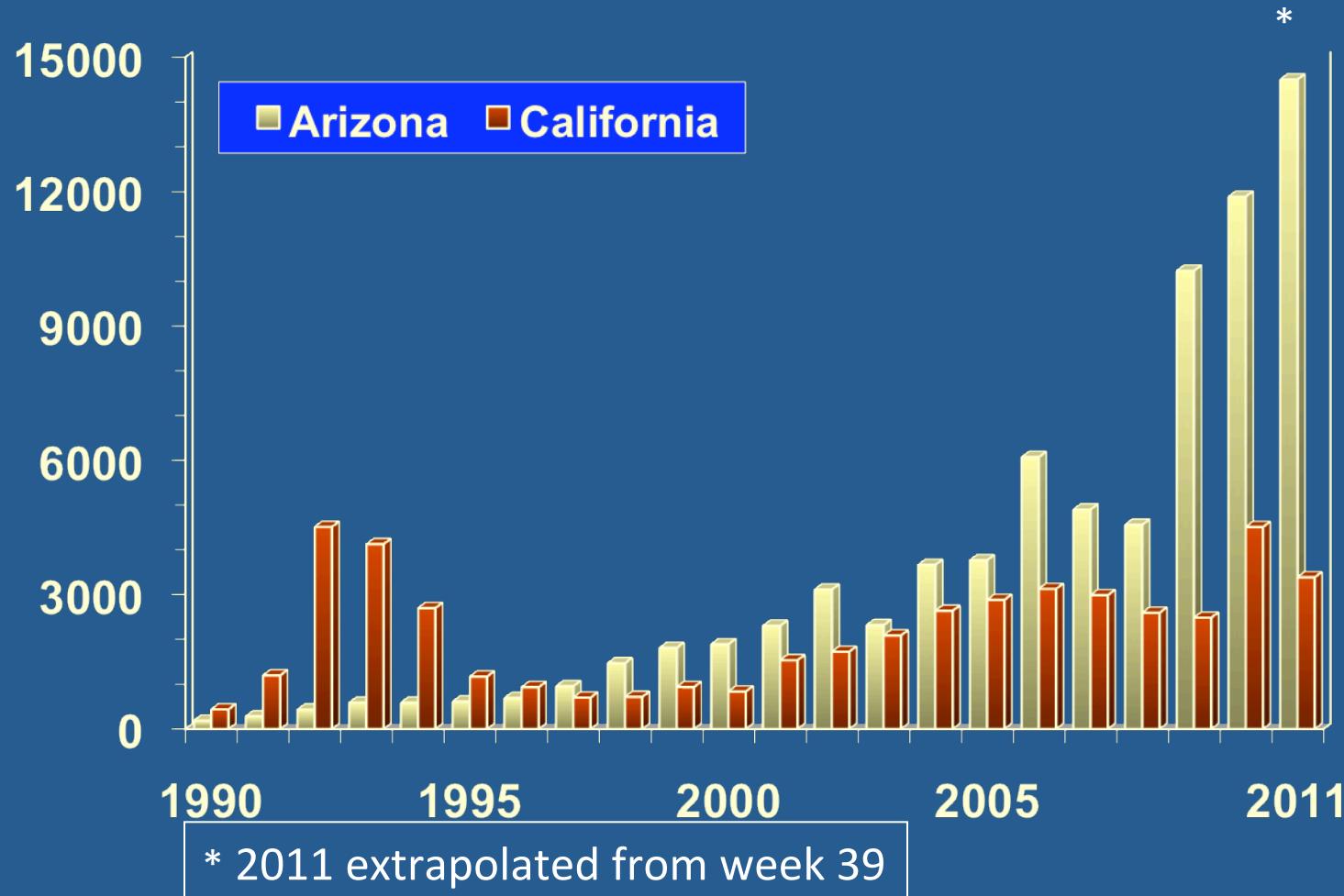


Andrew Comrie, 2000



Hector and Laniado-Laborin, 2002

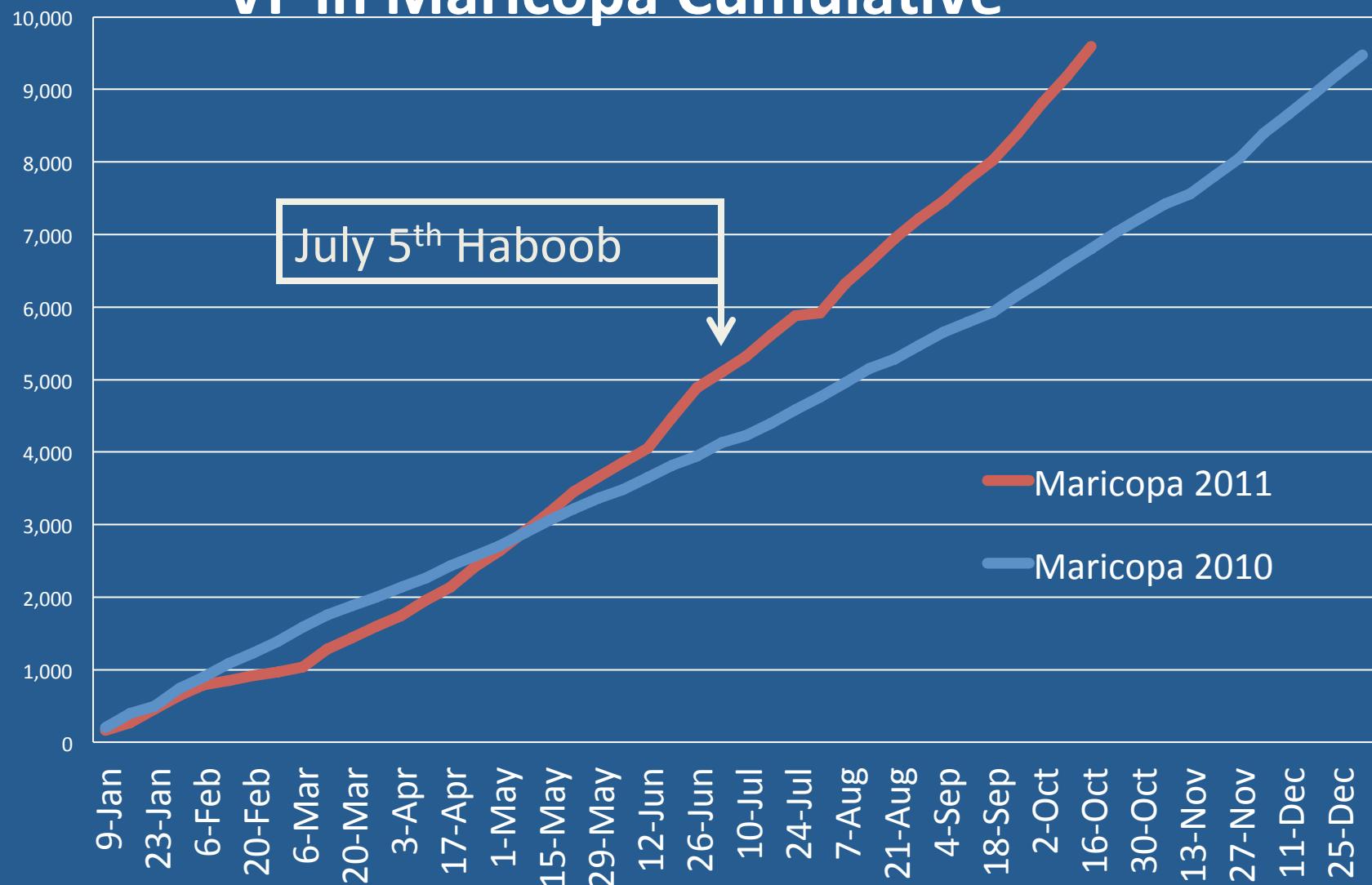
Reported Valley Fever



Courtesy: Infectious Disease Epidemiology

VF in Maricopa Cumulative

Cases to date



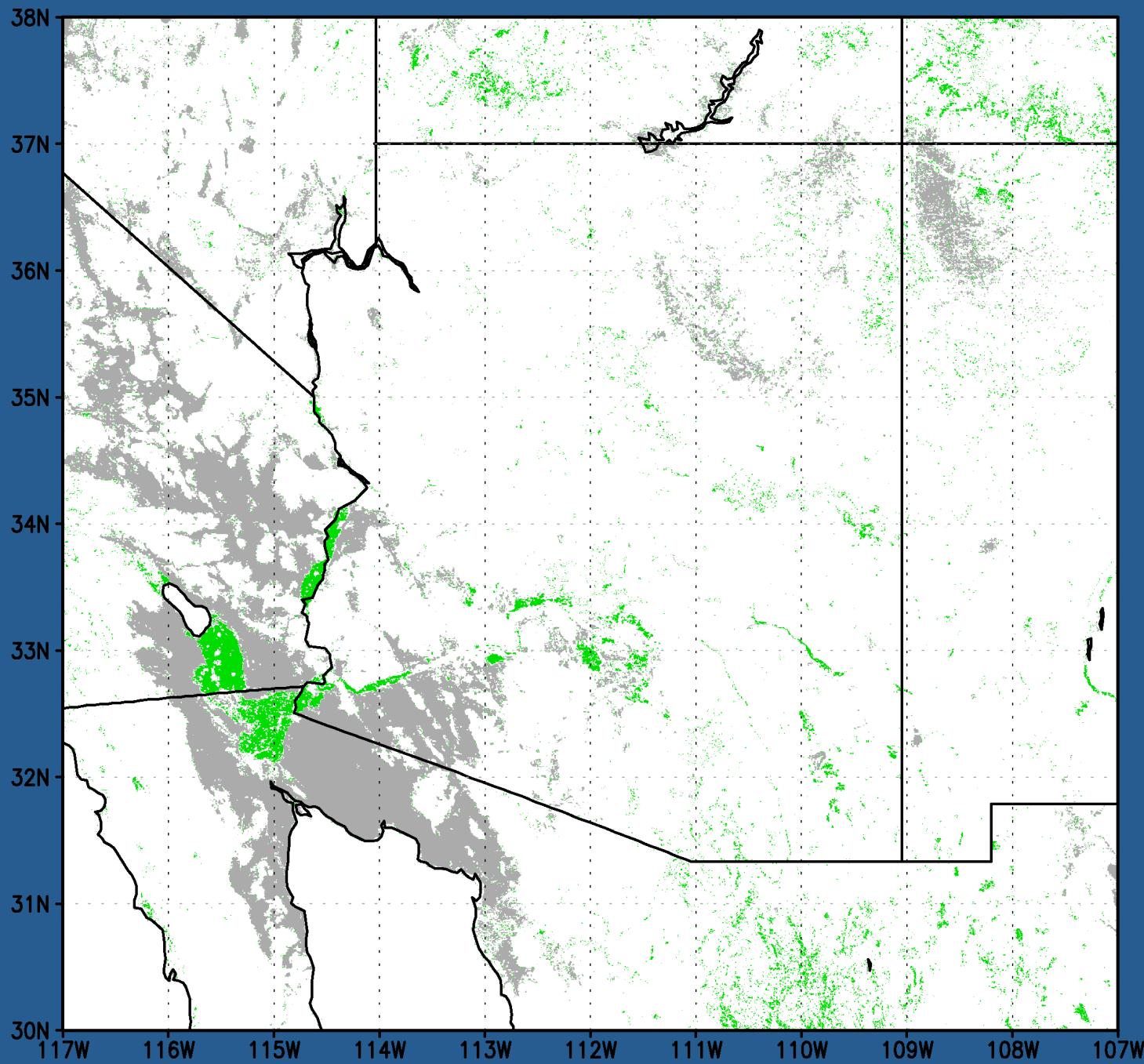
MCD12Q1

for 2009
(last available)

land cover types:

gray – barren

green – cropland



PATHWAYS TO ADDRESS AN IGNORED & GROWING PROBLEM

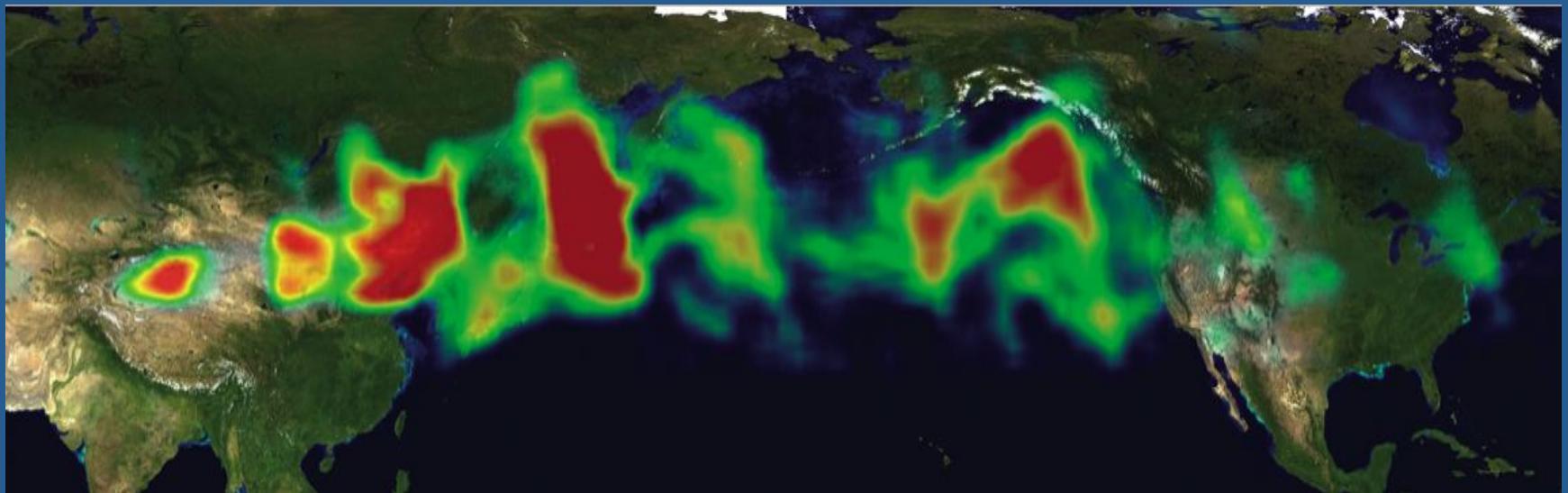
William A. Sprigg
Chapman University



Phoenix, Arizona, Tuesday, July 5, 2011

AP Photo/The Arizona Republic, Rob Schumacher

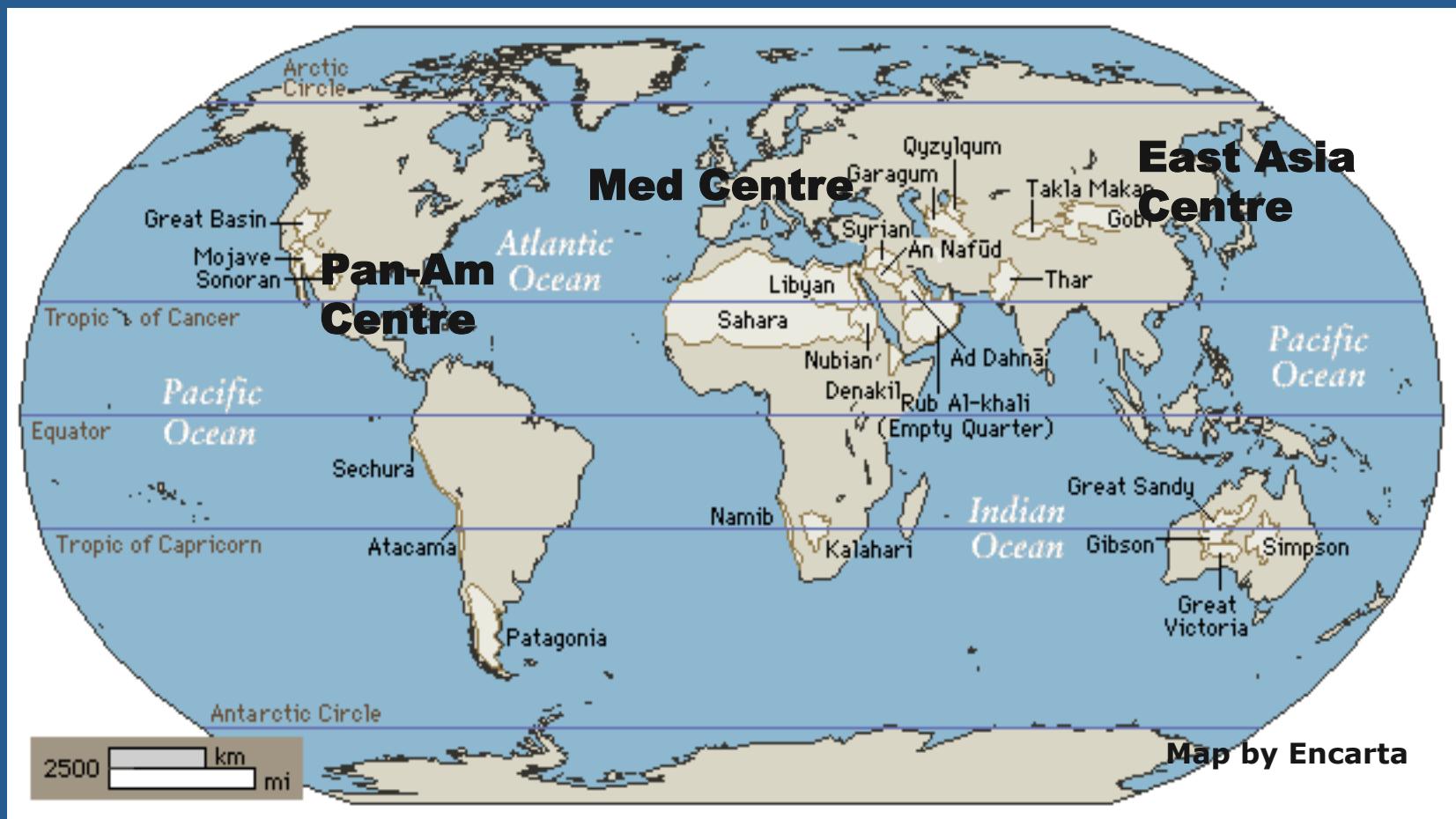
Desert Dusts Travel the World



**Satellite-derived Aerosol Optical Depth Over Several Days
in April 2001 (a NASA composite)**

Regional Centres

Hubs for Collaboration



**A Pan-American Center for the World Meteorological Organization
Sand and Dust Storm System**



Phoenix, Arizona -- 5 July 2011

A Pan-American Center for the WMO Sand and Dust Storm System

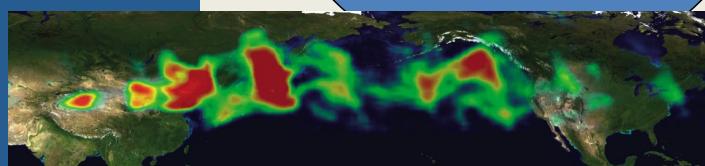
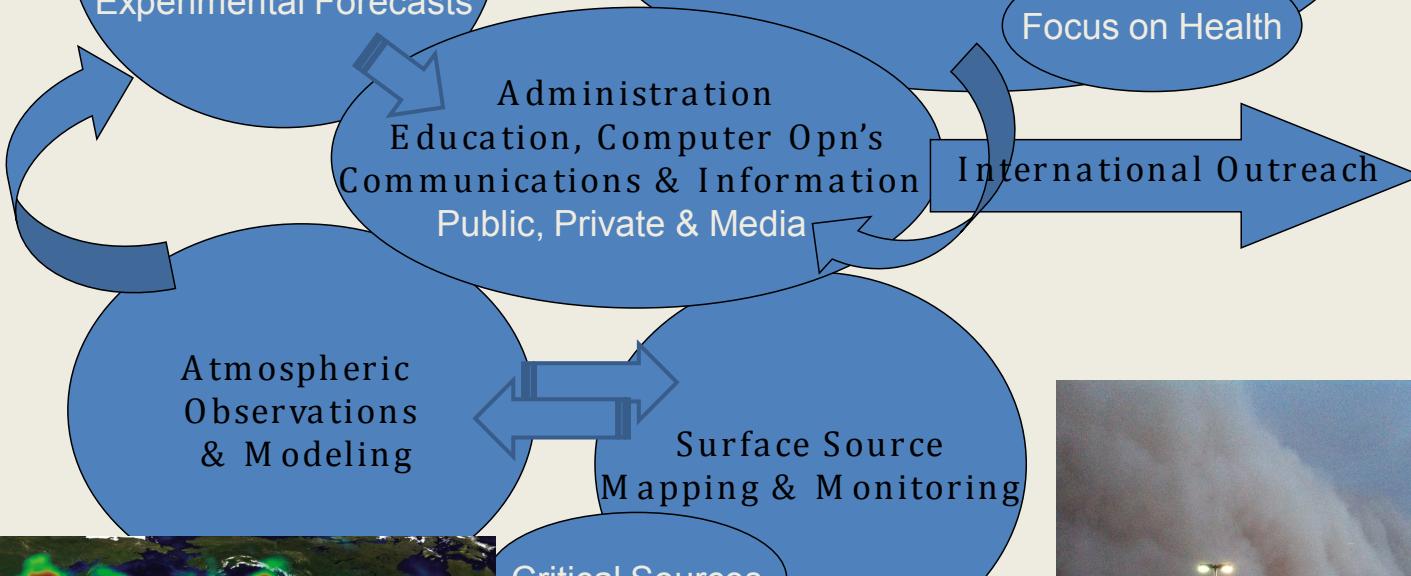
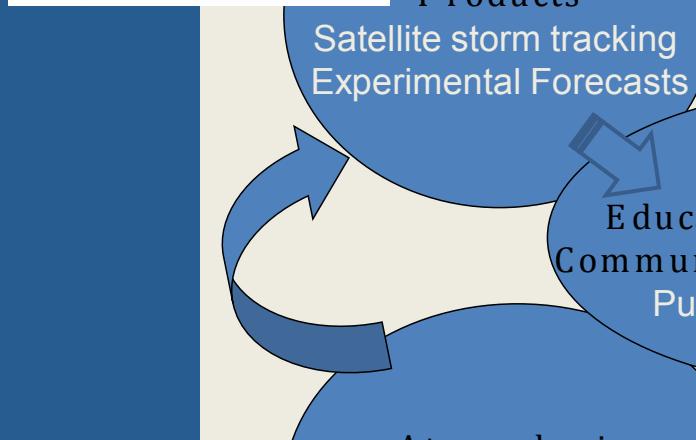
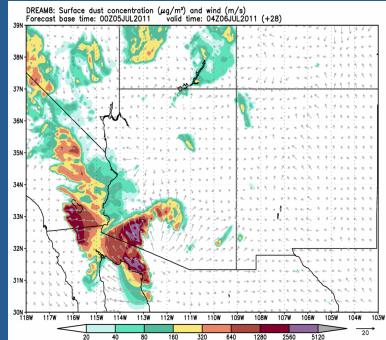
Opportunity:

- WMO Request
- History with Sand & Dust Storm Program
- Growing Capability
- Agency Sign-On

Significance:

- Visibility & Access
- Education
- Veteran Health & Safety
- Cardiovascular & Respiratory Health
- Highway & Airway Safety
- Water Resources
- Fishery Sustainability
- Improved Weather Forecasts
- Understanding Climate

The Pan-American Center for the World Meteorological Organization Sand and Dust Storm System



Gain from Investment

Membership

Visibility International

- WMO, WHO, WCRP, ACE-Asia ...

Access

North, Central, South America

- PAHO, weather services ...

U.S.

- NOAA, CDC, NIEHS, DOD, NASA, EPA, DOT, USDA, USGS

US West/Southwest

- State offices of AQ, Health, Transportation, Water Resources

California

- Health, Transportation Safety, AQ, Water Resources, Disaster Management, Fisheries

Orange County

- Community Service: International Visitors, Seminars, Business Networking

Chapman University

- Education

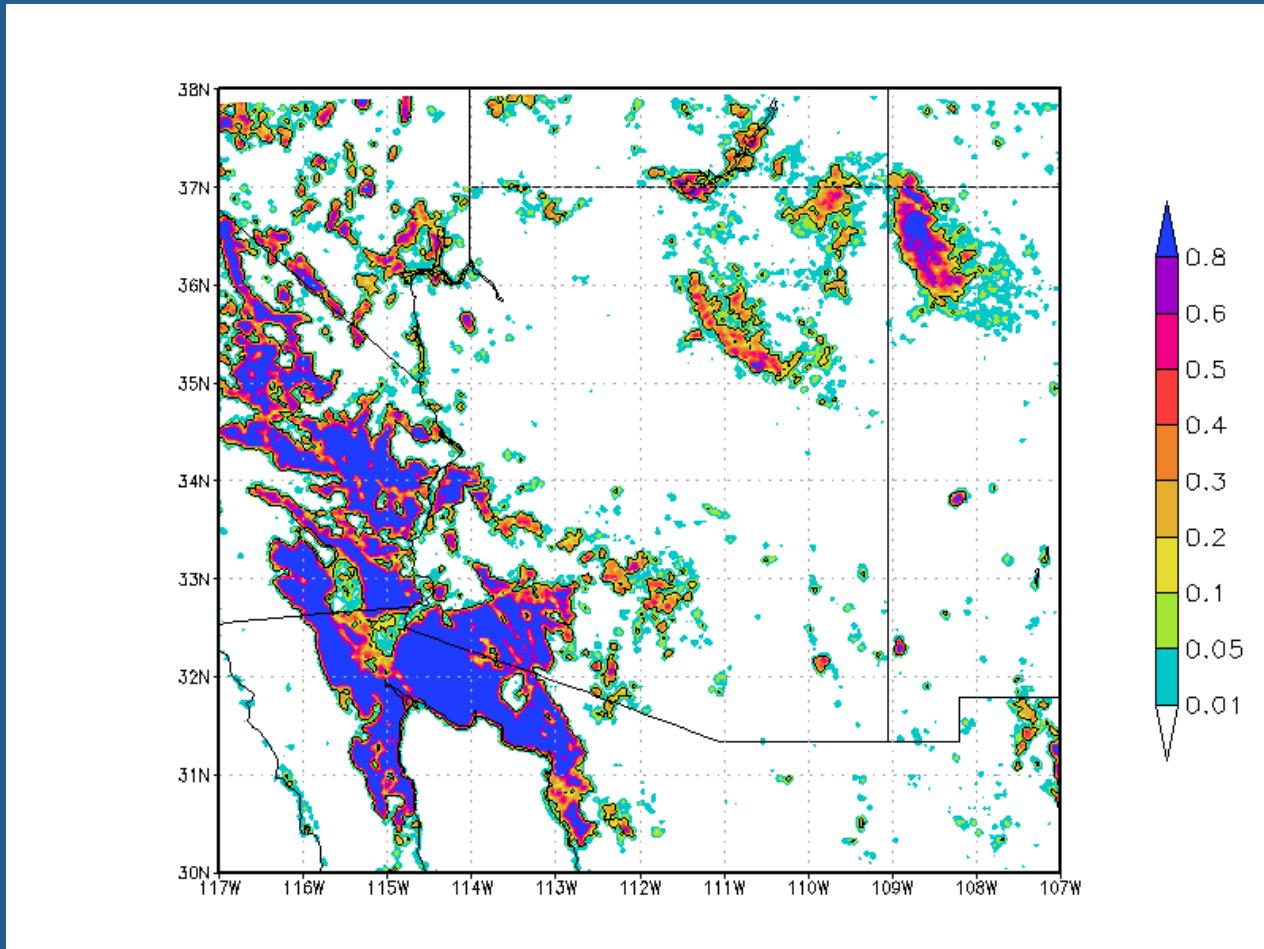
Pan-Am Centre Partners

- NASA/MSFC ?
- NASA/JPL ?
- Navy MRL
- Naval War College
- USGS
- NWS/NCEP
- NOAA/OAR
- NOAA/NCDC
- Environment Canada
- Collaborating Universities

WMO & Sister Centers: Barcelona & Beijing

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Thank You



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